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THE BRAMBLEY COLLECTION OF MAORI ARTEFACTS, AUCKLAND MUSEUM

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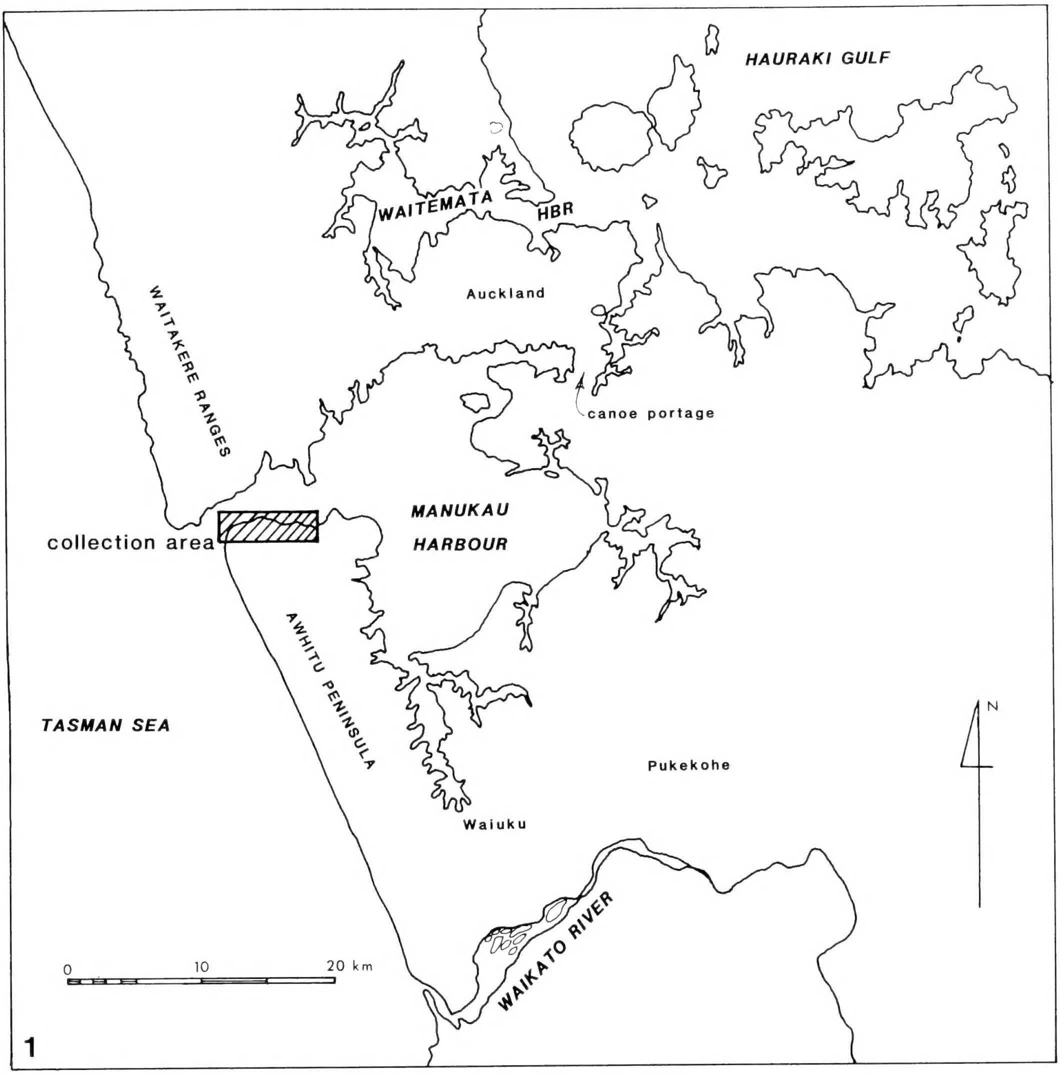
Abstract. The Brambley Collection of Maori artefacts from the Manukau South Head district includes the most important early, or 'archaic', assemblage of the Auckland region. Material recovered from N46-47/17, the Matatuahu site, on the southern shore of the entrance to Manukau Harbour, is most notable for its wide range of early adzes. The assemblage also has one-piece fishhooks of early form, a rare twin-lobed pendant rendered in Nelson serpentine, a harpoon point, files, drillpoints, *hoanga* (grinding stones) and a variety of flake tools and fragmentary stone material. Moa bone is probably industrial raw material and not evidence of moa hunting.

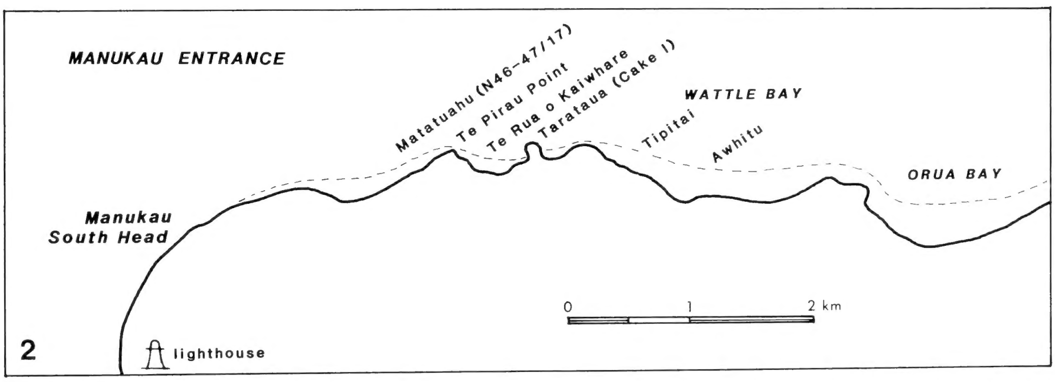
More adzes of early style are included in material in the collection which is not located to the Matatuahu site. Other items in this part of the collection are adzes of sub-rectangular (late) form, fishing sinkers, hammerstones and artefacts of European origin.

A thirteenth century date is suggested for the N46-47/17 site, when the immediate environment was probably very different and much more favourable to settlement than today. The site itself has suffered severely from sea erosion which has also carried away extensive areas of nearby sand flats, in all likelihood highly suited to Maori food cropping. Matatuahu is one of a number of sites which point to a reappraisal being required of the importance of early settlement on the west coast of the North Island.

In 1981 Mrs Mavis Brambley, now of Pukekohe, presented to the Auckland Museum a collection of Maori artefacts made over more than three decades by herself, her late husband and the Brambley family at Manukau South Head. The collection almost all comes from the Brambley farm 'Tipitai' (no longer in the family) and from the beach or foreshore from Wattle Bay *ca.* 4 km west to Manukau South Head (Figs.1,2). It includes characteristically 'archaic' material, late ('classic' Maori) material and artefacts of European origin. Where it can be clearly assigned, most of the early material comes from the so-called 'Manukau South Head' site (N46-47/17) west of Te Pirau Point, while the greater part of the late ('classic' Maori) and historic material comes from the shore about Wattle Bay and the Tipitai homestead.

The N46-47/17 material comprises the most important and comprehensive assemblage of archaic artefacts of any historic site in the greater Auckland region. In archaeological literature the site is commonly referred to as 'Manukau South Head' or 'Wattle Bay' (e.g. Davidson 1984:248). It is in fact 2 km west of Wattle Bay; nor is





Figs. 1,2. 1. Location of Brambley Collection area. 2. Provenance localities within the Brambley Collection area.

'Manukau South Head' a particularly appropriate name, applying more accurately either to the point of land which lies at the actual entrance to the harbour (2 km west of N46-47/17), or more generally to the district at the north end of Awhitu Peninsula.

It is proposed here that N46-47/17 be known as 'Matatuahu', which is the earliest documented name of the prominent headland at the east end of the site. This headland is named 'Jones Head' or 'Te Pirau Point' on the latest NZMS260 map. The Brambley family always knew it as 'Moses Rock'. The name 'Matatuahu' comes from the earliest detailed map of the district, which resulted from a February 1864 survey by S. Percy Smith (1865). Smith acknowledges the assistance of Rapata Kaihau and Kerei Aihipene in pointing out the boundaries of the various blocks of land. The same men are likely to be responsible for the many place names given on the map, including Matatuahu. Coulthard (1963) gives the name as 'Mata-a-tuhua' and ascribes the name to the "moa hunters camp site". 'Matatuahu', however, appears to have priority and probably the authority of Kaihau and Aihipene as well.

THE COLLECTION

The Brambley Collection mostly results from surface finds on the Tipitai farm and along the foreshore and inter-tidal area between Wattle Bay and South Head. In addition, material was recovered during excavations at the Matatuahu site in 1960 (see below).

The collection is strong in stone material. The relative lack of bone items reflects the common method of collection which was to patrol the beach after storms or exceptionally high tides. The erosion which brought stone items to light destroyed or swept away lighter bone material, this being especially so at the exposed Matatuahu site. Bone material in the collection results from the 1960 excavations at the site. The same applies to much of the less distinguished stone material. Mrs Brambley stated to the writer in 1982 that stone flakes including obsidian, chert and other material were found by excavation, ". . . otherwise they would not have been kept".

There are several separate groups of material within the Brambley Collection. As early as 1938 Mr Bill Brambley deposited 26 sinkers, three adzes, three grinding stones and a broken pounder, all localised to 'Wattle Bay', in the Auckland Museum (Ethnology Department catalogue numbers 23901-23904). In 1955 a further three items were deposited (34318-34320), all of which were subsequently uplifted by Mr Brambley in 1963 but which came in with the major part of the collection in 1981. In 1974 Mrs Brambley presented a limited quantity of material, mostly bone, with some stone flakes and other small artefacts, to the museum. This was originally catalogued into the Ethnology collection, but has now been transferred to the Archaeology Department in order to bring most of the Brambley material together (catalogue numbers AR7353-7400). The main Brambley collection came into the museum in 1981 (AR6883-7352, AR7401-7405 and AR7410). The 1938 deposit remains in the Ethnology Department.

In January and February 1960 excavation was carried out at the Matatuahu site by the Brambleys with the assistance of Mr R.G.W. Jolly of Papakura (see Brambley

1966:115-118). Some important artefacts which resulted were retained in the Brambley Collection; less spectacular material was passed on at the time to the University of Auckland Anthropology Department by Mr Jolly. All material held in the university collection was transferred to the Auckland Museum in July 1982, where it received a single catalogue number (AR7417) having already had detailed cataloguing in the university collection. The January-February 1960 excavation material is catalogued under university collection numbers AU265-293, AU313-321, AU346-365, AU390-406, AU409-413 and AU454.

When Mr Jolly drew the attention of the University of Auckland Archaeological Society to the importance of the Matatuahu site, an excavation was carried out by the society over one weekend in November 1960. An important chisel (AR6905; see Fig.9), found during this work, was retained in the Brambley Collection. All other material was held in the university collection until July 1982 when it too was transferred to the Archaeology Department of the Auckland Museum (AR7417; university catalogue numbers AU1403-1417, AU1422-1428). A further small collection from N46-47/17, now in the museum, is marked "Wattle Bay 28/11/65 Trower and Jolly" (AR7445), and results from work done at the site in 1965 by Messrs R.G.W. Jolly and David Trower.

There have been several episodes of cataloguing and recording the Brambley Collection, the most important of which resulted in a typescript catalogue prepared by R.G.W. Jolly and R.G. Law in 1977-78. In the early 1960s W. Ambrose and J. Golson prepared a catalogue of 62 items in the collection, with notes on provenance in each case. This catalogue is reproduced in the Jolly and Law manuscript. The Ambrose and Golson catalogue relied upon numbered stickers attached to catalogued items. These have since come off the artefacts, but a few survived when the Jolly and Law catalogue was prepared to allow some cross referencing. Thus some, but not all, of the provenance information in the Ambrose and Golson catalogue is still useful.

In 1972 D.R. Simmons examined the collection and wrote brief locational information in pencil directly on many items according to information from Mr Brambley. Most importantly, Jolly and Law catalogued 412 items from the collection in 1977-78, giving each a unique number (BR1-BR412) which was written on the artefact in black ink. These numbers are now duplicated by the museum 'AR' (Archaeology Department) catalogue numbers which are used in the present report.

Information on the provenance of material in the collection thus comes from four sources: the Ambrose and Golson data where the stickers survived until 1977-78, plus those few additional items which can be identified from their catalogue descriptions; Simmons' 1972 pencil notes on the artefacts themselves; the Jolly and Law catalogue listing which locates 10-12 further items; and Mrs Brambley's recollection to the present writer in 1982.

In the following description of the Brambley Collection, material assigned to the Matatuahu site is treated first, followed by material recovered from elsewhere in the Wattle Bay/Tipitai/Manukau South Head district. The rare items from elsewhere in New Zealand are dealt with briefly in Appendix 1.

THE MATATUAHU SITE (N46-47/17)

ADZES AND CHISELS

More than thirty adzes, chisels and substantial pieces thereof are located to the Matatuahu site. The assemblage is unparalleled in the Auckland region and possibly the North Island for its archaic character. It includes chisels, 'hogback' (Duff Type 4A) adzes, adzes of rectangular and triangular cross-section, side-hafted adzes, 'Samoan' Duff Type 2C adzes and an adze of lenticular cross-section. More archaic material in the Brambley Collection is not located to the Matatuahu site but comes from the nearby Tipitai farm and foreshore. It is thus treated here among material from other than the Matatuahu site, although it cannot be ignored in assessing the archaic character of the collection as a whole or the Tipitai/South Head locality.

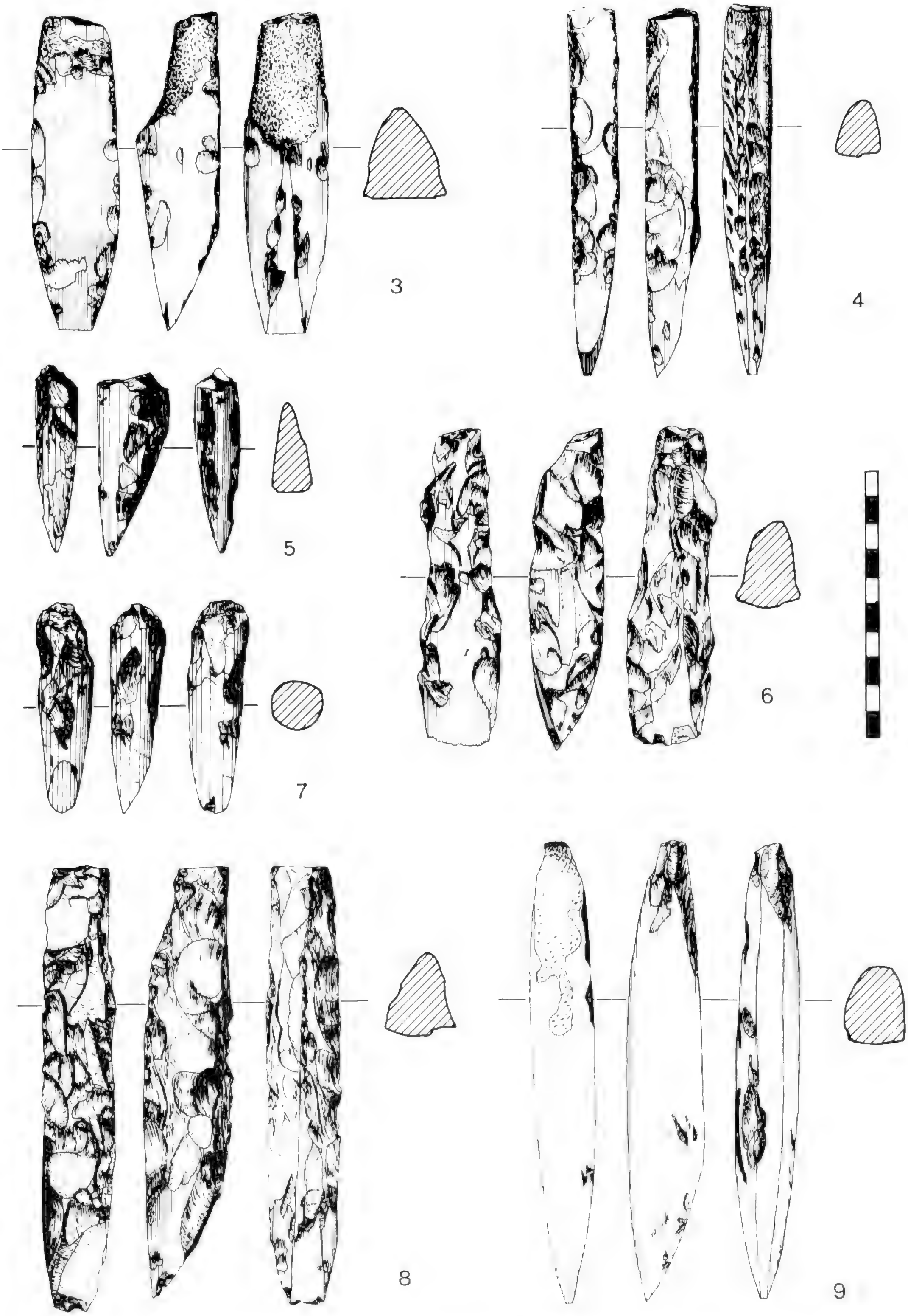
Chisels

A group of chisels of early form include some of the outstanding items of the collection. Six of the items come from the Brambley excavation area of early 1960, another was found during the University excavation of November the same year. Four chisels, made of black metasomatised argillite from the Mt Ears source, D'Urville Island, are important among the few pieces in the collection made of this supreme adze making material.

AR6902 (Fig.3) was found during the Brambley excavation of early 1960 by Messrs Brambley and Jolly (see Brambley 1966:117-118). It was in direct association with a *Dinornis novaezealandiae* tibiotarsus (AR7272), a small Type 1A adze (AR6897, Fig.16), and a reworked broken adze of Tahanga basalt (AR6899, Fig.15). It is a small Type 4A 'hogback', superbly rendered, with a high degree of polish except for the marked reduction at the lashing end which is finely hammer-dressed. There is some edge damage to the blade. All angles are sharply and accurately finished. It measures 118 mm long with a 12 mm wide blade.

Another chisel of outstanding craftsmanship from the area of the Brambley excavation is AR6907 (Fig.4). It was found by Mrs Brambley in association with a small gabbro pebble (AR7027). AR6907 is a narrow chisel with a slight lateral curve, finely flaked with some hammer-dressing at the margins. Polish extends down both sides and along the narrow front. On the back the bevel only is polished. The chisel is 136 mm long, but may be incomplete. The fine blade is 3 mm wide.

Again of Mt Ears argillite and from the Brambley excavation area is a remarkable gouge of which only the working end remains (AR6949, Fig.5). Of narrow 'hogback' form, apparently similar to AR6907 and AR6905, this item is unusual in that the 'front' rises to a narrow ridge which continues to a point, rather than to a blade however narrow. Like the complete items of this material, AR6949 displays skilled workmanship in its manufacture and a high degree of polish over flake scars. The surviving fragment is 70 mm long and 17 mm at its widest. A 26 mm depth suggests an overall length of approximately 170 mm (c.f. AR6905, Fig.9).



Figs. 3-9. Chisels, Matatuahu site. 3. AR6902. 4. AR6907. 5. AR6949. 6. AR6928. 7. AR6937. 8. AR6910. 9. AR6905.

The fourth item made of the same material again comes from the 1960 Brambley excavation area. AR6928 (Fig.6) is a triangular cross-sectioned chisel. It is well flaked, with a high degree of polish in places and rough polish elsewhere, suggestive of reworking from a larger item. The length is 117 mm, and blade width, 22 mm.

An important and unusual chisel is illustrated in Fig.7. AR6937 was found by R.G.W. Jolly, also in the Brambley excavation area. It is made of the highly characteristic veined metasomatised argillite from Ohana at the south end of D'Urville Island. It falls into Duff's (1956:184, 190-192) Type 6, of round-sectioned chisels or gouges. Skinner (1974:110-111) locates this type to the South Island, while Duff notes Chatham Islands examples; both remark on formal parallels with later nephrite (jade) carving chisels. The Matatuahu example is 78 mm long with a strongly curved blade *ca.* 7 mm wide. Beneath the polish rough flake scars and hammer-dressing illustrate the difficulty of reducing the material to a round cross-section.

The raw material of AR6910 (Fig.8) comes from the beaches and rivers of the west side of the inner Hauraki Gulf and belongs among the Waiheke Group greywackes (Schofield 1967). The superbly crafted 'hogback' chisel is made of fine-grained green Waiheke Group greywacke: skilful flaking shows the high degree of control that was possible with the material. Minimal polishing is concentrated at the blade end. The blade itself is damaged so that the length of the chisel was marginally longer than the present 164 mm. The blade width would have been little different from the present 11 mm.

The chisel AR6905 (Fig.9) was found during the university excavation of November 1960 in association with bone, possibly moa bone. It is made of a dark basalt from the Tahanga source, Opito Bay, Coromandel Peninsula. It is almost completely polished except where flake scars show. The length is 170 mm and blade width, 2.5 mm.

Side-hafted adzes

Three side-hafted adzes are important indicators of the antiquity of the Matatuahu site — this form being early in the New Zealand sequence as Moore *et al* (1979) have shown. Mrs Brambley recalls that she found AR6918 (Fig.12) in a beach pool below the waterfall at the east end of the site "... almost directly below the [lobed] pendant."

Two of the three side-hafted adzes are made from identical fine-grained green Waiheke Group greywacke, to very closely similar forms. The larger adze is 253 mm long with a blade 93 mm wide (AR6941, Fig.10); the smaller is 181 mm long with a blade 86 mm wide (AR6922, Fig.11). Both adzes lack any polish and are roughed out only, with a small amount of hammer-dressing. The third adze (AR6918;Fig.12) is of light grey basalt from the Tahanga quarry at Opito, Coromandel Peninsula. It is 201 mm long with a comparatively narrow (74 mm) blade. This adze has more hammer-dressing than the others and has a well polished blade.

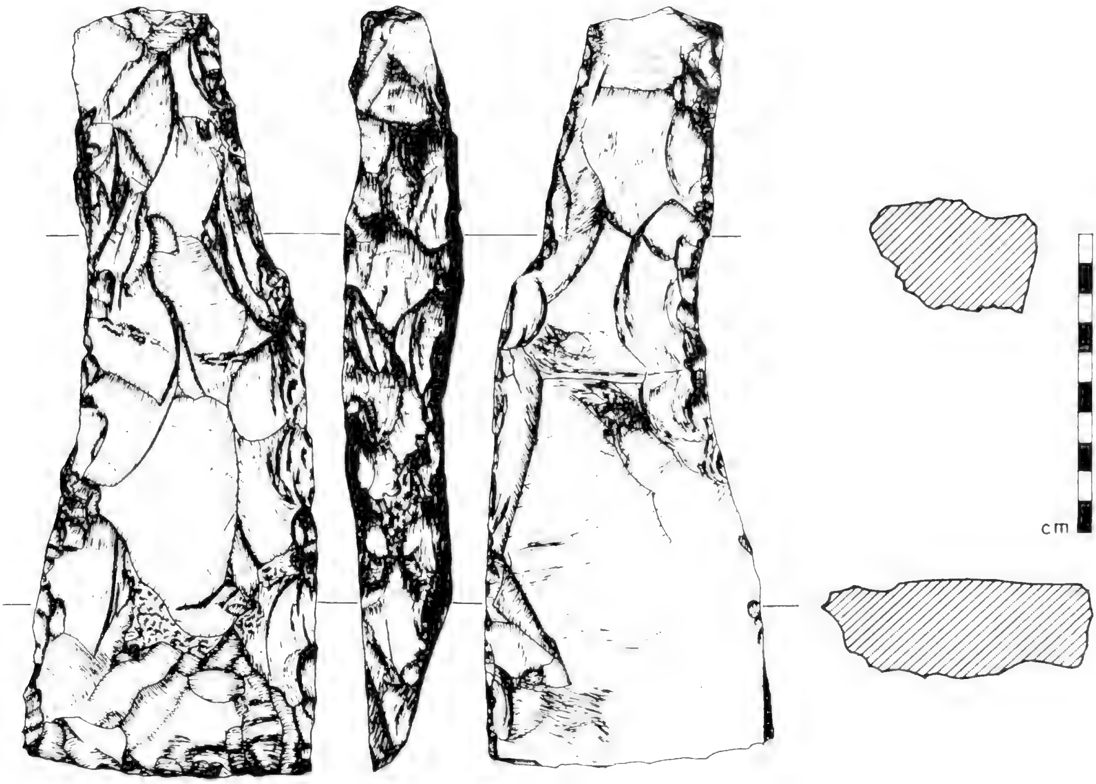


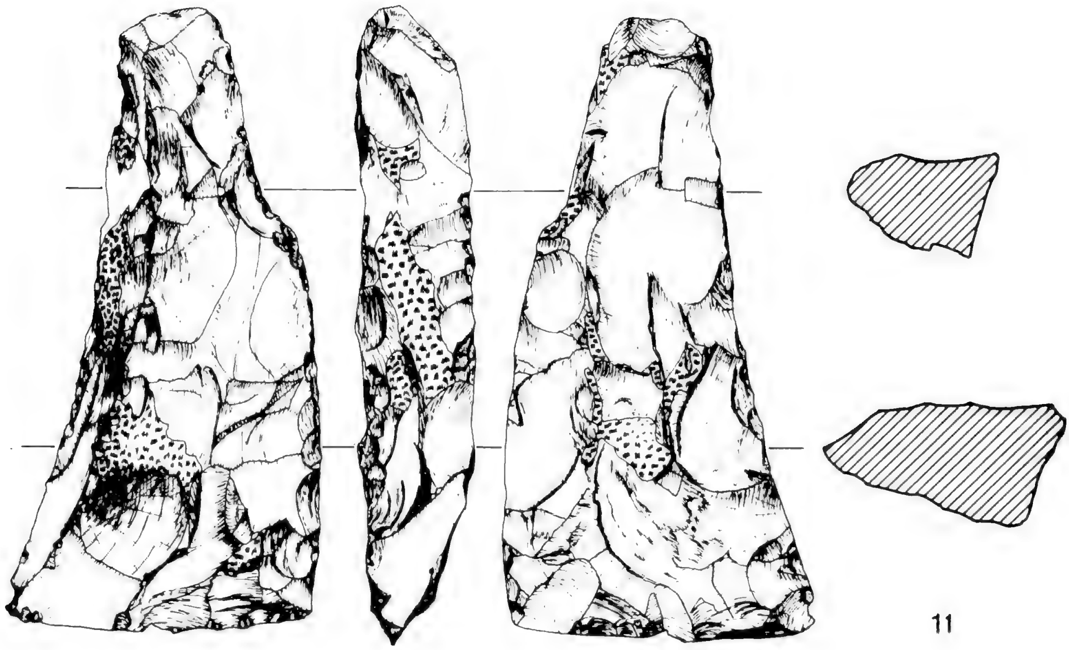
Fig. 10. Side-hafted adze, Matatuahu site. AR6941.

Rectangular adzes of early form

Several items in the Brambley Collection represent the characteristic early adze of rectangular cross-section. Among them is one example of the Type 1A, ". . . the broad-bladed adze quadrangular in section, and with a marked 'tang' or 'grip' ", which Duff (1956:146) describes as, ". . . probably the most distinctive adze type ever evolved by the Polynesians." Where it can be determined the other adzes of quadrangular form are without tang.

The quadrangular adze without tang — the Duff (1956:161-170) Type 2A — is represented by AR6944 (Fig.13). The origin of this adze is not entirely certain: the Ambrose and Golson catalogue states that it was found on the foreshore in front of the Brambley site, which has confirmation from Simmons' pencil note on the adze itself ("Below B Dig 1"). Mrs Brambley, however, recalls that the adze was found west of the site on the shore beneath the lighthouse. The item measures 267 mm in length and 77 mm across the now damaged blade. It is made of Tahanga basalt. There is minimal polishing of the blade and high points on the sides. Haft rubbing is highly visible on the front and back and use-wear can be seen on the blade.

Two smaller adzes of strongly rectangular cross-section are also located to the Matatuahu site, in both cases to the Brambley excavation area. AR6901 (Fig.14) is



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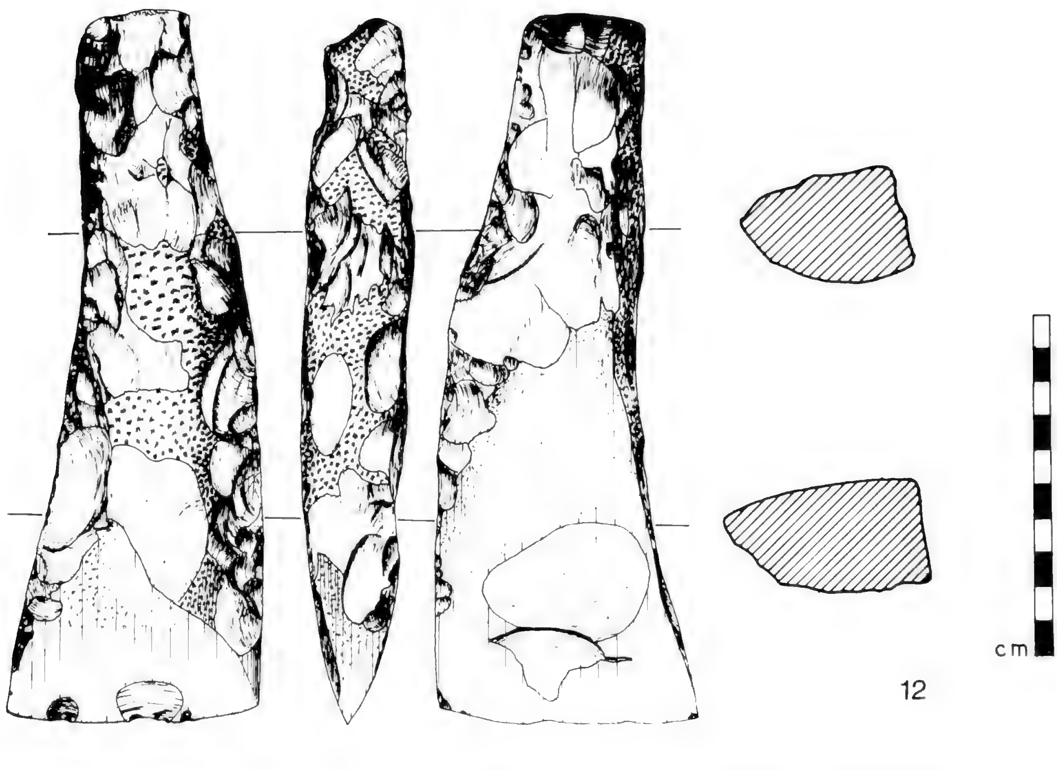

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Figs. 11,12. Side-hafted adzes, Matatuahu site. 11. AR6922. 12. AR6918.

made from a fine-grained green sandstone. Overall polish does not obscure heavy flaking scars. The length is 115 mm and blade width 48 mm. AR6899 (Fig.15) was found with AR6897 and AR6902 beneath the *Dinornis novaezealandiae* tibiotarsus (AR7272). In this case a fragment from a larger adze is being reworked, which retains on the front the highly polished surface of the original item, the remainder being accurately flaked. The material is pale grey Tahanga basalt. The adze measures 119 mm in length and 43 mm across the blade.

Fig.16 shows the only Type 1A adze in the collection. AR6897 was also found during the Brambley excavation of early 1960 in direct association with the *Dinornis novaezealandiae* tibiotarsus, the adze AR6899 (Fig.15) and the chisel AR6902 (Fig.3). AR6897 is 133 mm long, with a blade 52 mm wide. It is made of black basalt from the Tahanga source (Simon Best, pers. comm), representing the black end of the pale grey to black Tahanga range. It is well finished by polishing and hammer-dressing; haft polish is present over hammer-dressing at the back.

Two fragments complete the material of rectangular cross-section from the Matatuahu site. A well finished blade portion of dark grey Tahanga basalt (AR6929) indicates an adze as large or larger than AR6944 — perhaps 300 mm in length. Half of a well finished adze in Tahanga basalt has a blade width of 63 mm (AR6914).

Triangular cross-sectioned adzes

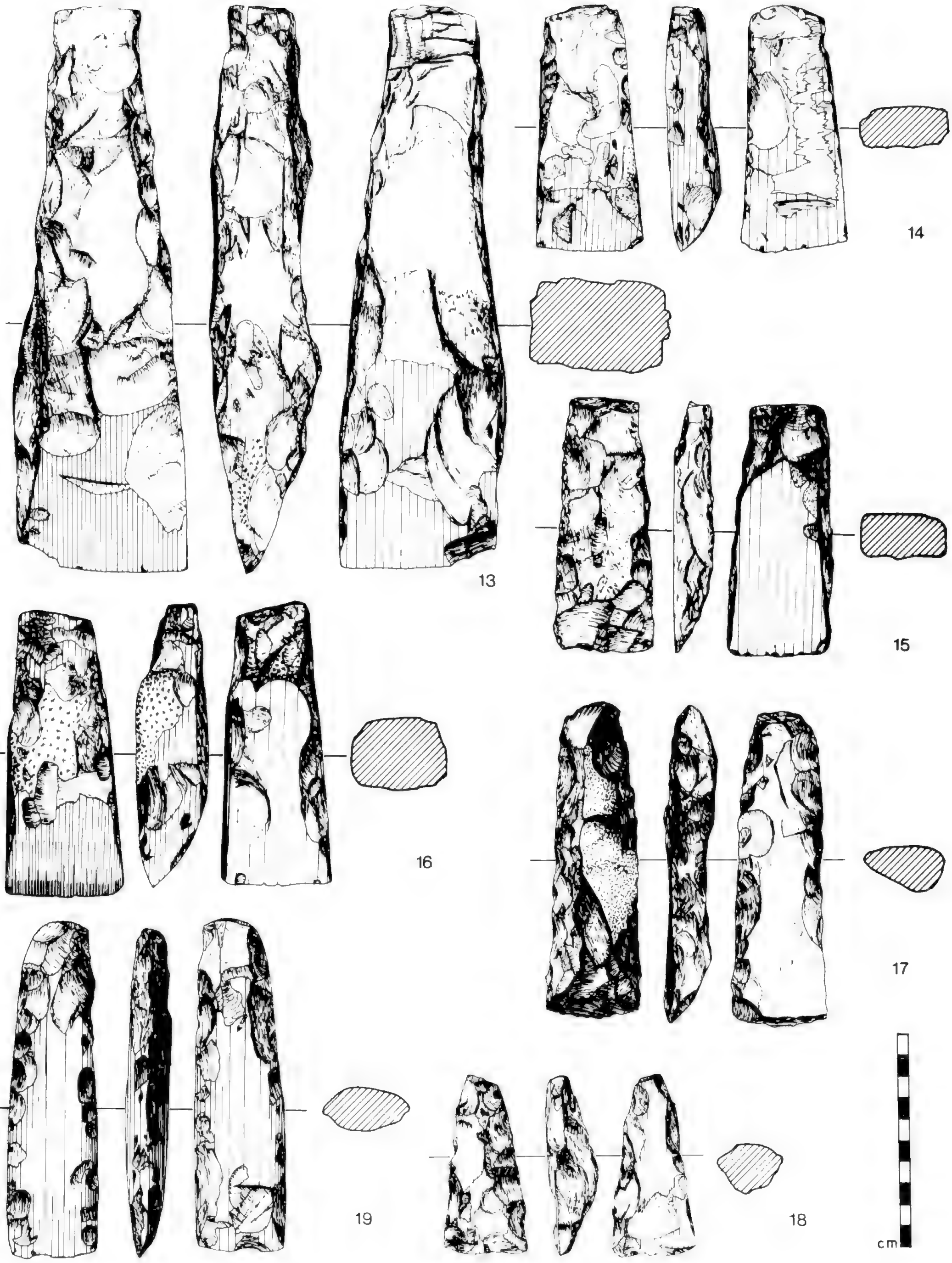
Duff (1956:170-176) describes early Polynesian adzes of triangular form, often of shallow cross-section in New Zealand examples. The form is well represented in the Brambley Collection by the untanged Duff Type 3B. In addition there are a number of smaller adzes and fragments which, though of triangular section, are less easily assigned to an early date. Not all Duff Type 3B adzes in the collection are from the Matatuahu site: the most outstanding items are not properly located (see Figs.140,141).

AR6938 (Fig.17) is made of light grey Tahanga basalt. It is in roughed-out form, retaining a large area of original patina on the front. It measures 148 mm in length and 43 mm across the blade. A reference in the Jolly and Law catalogue indicates that this item came from the Brambley excavation area.

A small triangular cross-sectioned adze is shown in Fig.18 (AR6980). The Ambrose and Golson catalogue states it was "dug out of the main culture level at Brambley's site." It is made of light grey Tahanga basalt and is relatively crudely flaked with some polishing, especially on the front. There is a marked reduction towards the butt end. Measurements are 84.5 mm length and 35 mm blade width.

Lenticular cross-sectioned adze

One of the most remarkable items of the entire collection is AR6908 (Fig.19). This adze is of strongly lenticular cross-section. Its discovery beneath moa bone within the Brambley excavation area confirms its archaic character. It is made of fine-grained



Figs. 13-19. Adzes of rectangular, triangular and lenticular cross-section, Matatuahu site. 13-16. Rectangular cross-sectioned adzes. 13. AR6944. 14. AR6901. 15. AR6899. 16. AR6897. 17,18. Triangular cross-sectioned adzes. 17. AR6938. 18. AR6980. 19. Lenticular cross-sectioned adze. AR6908.

green Waiheke Group greywacke and has a high degree of polish over skilful flaking from the two margins. The adze bears a resemblance to Skinner's Type VII (Skinner 1974:111) but does not have the 'coffin' shape truly characteristic of the type. The length is 156 mm and blade width 39 mm.

'Hogback' adze

Duff's (1956:176-184) Type 4 is, like the side-hafted and the triangular cross-sectioned Type 3B adze, an early form in the New Zealand sequence. Again it can be paralleled elsewhere in eastern Polynesia.

In addition to AR6902, already dealt with under chisels, only two items of this adze type are known to come from the Matatuahu site. AR6930 is the strongly hammer-dressed and well shaped butt end of an adze, made of fine-grained green Waiheke Group greywacke. It was found during the Brambley excavation of 1960. The complete adze was probably *ca.* 250 mm in length. AR6930 is illustrated with other Type 4 material (Fig.147).

From the beach in front of the Brambley excavation comes a butt fragment (AR6968; not illustrated) in pale grey Tahanga basalt, with original patina at the end. This also has the appearance of having belonged to a Type 4A adze perhaps of 200-250 mm length.

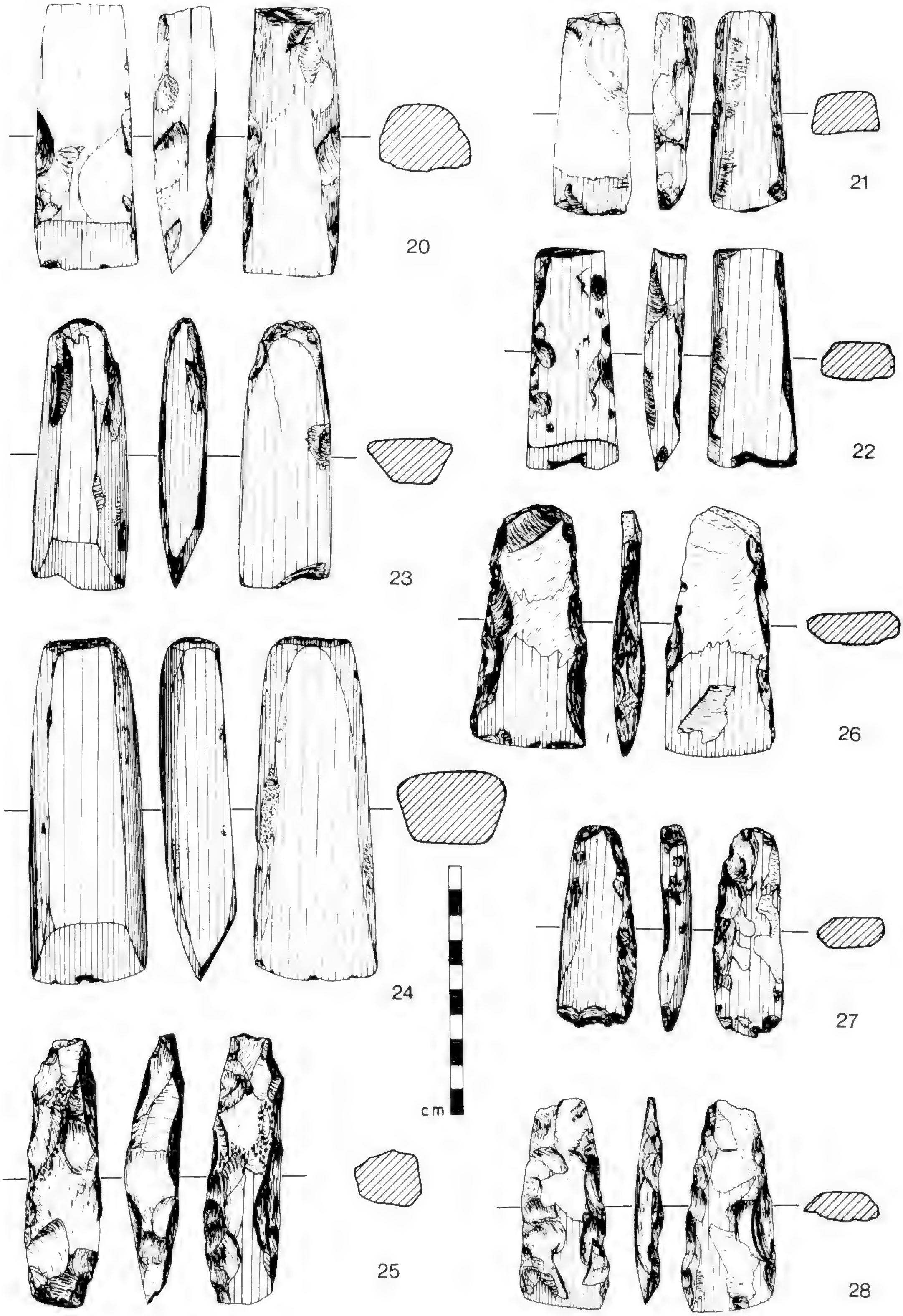
'Samoan' type adzes

Three adzes from the Matatuahu site fall into Duff's (1956:168-169) Type 2C form, of sub-rectangular cross-section with the back wider than the front. Duff follows Skinner (1974:107) in characterising it as the 'Samoan Type' from its prevalence in Samoan assemblages where it is commonly larger than the examples given here (Green 1974). Duff and Skinner both note its association with early sites; neither had seen an example from the North Island. All three adzes are provenanced to the Brambley excavation area, and all three are made of black Tahanga basalt.

The best example of the type is AR6884 (Fig.20). This has a high degree of overall polish with sharply defined margins except at the front which is notably rounded, especially towards the butt end. Haft polish is apparent on the back as far as the sharply defined, high angle bevel. Length 108 mm, blade width 34 mm. Less distinguished are AR6909 (Fig.21) and AR6924 (Fig.22). The former is a small flake adze, again with sharp edges, and overall polish except where the flake scar is apparent on the back. The steeply angled bevel ends at a battered blade. Length 80 mm, blade width 27 mm. AR6924 also has overall polish, sharp margins and a steep bevel to a battered blade. It measures 88 mm in length, with a blade width of 34 mm.

Miscellaneous adzes of sub-rectangular form

A small group of adzes from the Matatuahu site are more nondescript in form. AR6891 (Fig.24), for example, could as easily belong to any late assemblage. The adze



Figs. 20-28. 'Samoan type' and other sub-rectangular adzes and flake adzes, Matatuahu site. 20-22. 'Samoan type' adzes. 20. AR6884. 21. AR6909. 22. AR6924. 23-25. Miscellaneous adzes of sub-rectangular form. 23. AR6898. 24. AR6891. 25. AR6939. 26-28. Flake adzes. 26. AR6927. 27. AR6920. 28. AR6932.

was found on the beach between the Brambley excavation area and Te Pirau Point. It has a high degree of polish, with extensive haft rubbing at the butt end indicating a great deal of use. The overall polish makes the raw material difficult to determine, but it appears to be a dark greenish-grey fine-grained basalt or metamorphosed sandstone. The length is 137 mm and blade width 44 mm.

AR6898 (Fig.23) is a small adze of almost triangular section, probably of black Tahanga basalt. It was found eroding from the dune face only 2 m west of the University excavation area of November 1960. It has an overall polish on its sharply angled faces and measures 108 mm in length and 34 mm across the now damaged blade. Another adze of black Tahanga basalt (AR6923) is of similar, though unfinished, form; the length is 106 mm and the width 44 mm. The blade is very badly battered and may be in the process of being reworked. It comes from the Brambley excavation.

AK6939 (Fig.25) is fashioned from part of a broken adze but remains unfinished. It was found in the Brambley excavation and is made of grey Tahanga basalt. Part of the front retains the highly polished surface of the original adze, the remainder is flaked to a roughly rectangular form with some hammering in places. Length 107 mm, blade width *ca.* 20 mm.

Not illustrated is AR6956, the butt of a massive deep-sectioned adze from the Brambley excavation area. It is made of black Tahanga basalt. The available cross-section is strongly rounded over the basically rectangular form and is extensively hammer-dressed front and back with polish visible down the sides. The original length may have been 250-300 mm. A similar fragment of a smaller adze was found on the beach below the Brambley excavation area (AR6968). In this case the raw material is light grey Tahanga basalt and the fragment is highly polished with original patina at the butt end. AR6968 comes from an adze of deep cross-section which may possibly have been of 'hogback' form.

Flake adzes

A group of small adzes formed by minimal lateral reduction and somewhat cursory polish still bear the curved shape of their flake origin. All come from the area of the Brambley excavation.

AR6927 (Fig.26) is flaked along the margins, with only the blade end polished. The butt end retains the original patina. Typical of flake adzes, it has a shallow cross-section. Length is 97 mm, blade width 43 mm. AR6920 (Fig.27) is a reworked flake from the margin of a larger adze. Polish at the bevel and back is all that has been required, the front already being highly polished. The length is 79 mm, the badly battered blade is 27 mm in width. AR6932 (Fig.28) is of black Tahanga basalt with minimal polish near the blade front and back. Length 83 mm, blade width 32 mm.

Other adze fragments

Twenty-four further pieces of adzes or chisels included in the Brambley Collection

are said by Mrs Brambley to have come from the Matatuahu site. Brief information on the material is given in Table 1.

Half of this broken material is Tahanga basalt, with almost half the remainder Waiheke Group greywacke. Also represented are gabbro, black Mt Ears argillite, another, grey, high quality metasomatised argillite from the Nelson region and other basalt and argillites.

TWIN-LOBED PENDANT

One of the most important items in the Brambley Collection is a twin-lobed pendant, one of only ten examples of the form (AR7000, Fig.29; see Prickett 1985). It was found in the 1950s by Mrs Brambley just west of the rocky headland of Te Pirau Point at the start of the dune face, that is, at the extreme eastern end of the site. It is made of deep green/black serpentine with some pale green inclusions, almost certainly from the Nelson region. It measures 41 mm in width, 30 mm in height and 27.5 mm in depth, and weighs 44.8 g.

The Matatuahu pendant is the only example of the form unequivocally located north of the Cook Strait region. Of the others, five were found on the northern shore of the South Island, three on the North Island's south-west coast, with one uncertainly provenanced to Portland Island (Hawkes Bay) or possibly the Nelson district (Prickett 1985).

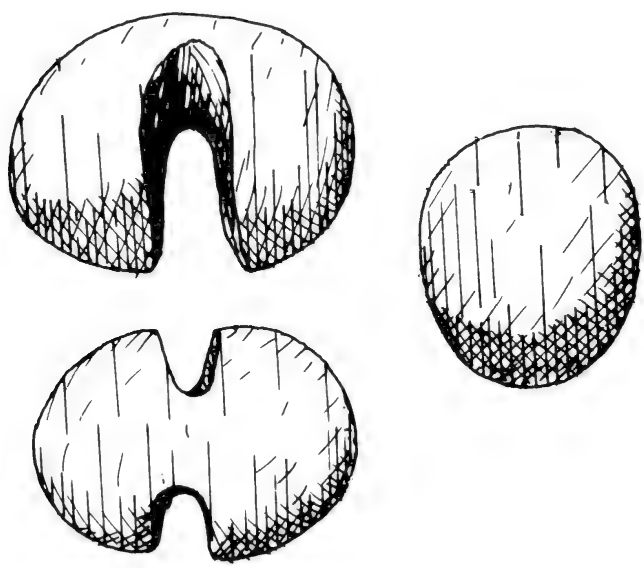


Fig. 29. Twin-lobed pendant from the Matatuahu site. Above left. Front view. Below left. Top view. Right. End view.

Table 1. Matatuahu site adze fragments.

AR	Description	Measurements of fragment	Raw material
6940	Crude rough-out of shallow triangular cross-section.	134 x 61 mm	Coarse trachyte
6950	Blade fragment of highly polished adze — probably of 2B form *ca.* 160-200 mm in length.	105 x 22 mm	Black basalt
6951	Central part of small, highly polished adze of 2B form. Hammer-dressed at sides.	57 x 37 mm	Green argillite — c.f. Taranaki material
6952	Central part of well-finished adze — possibly 2A form. Polished over flake scars.	105 x 59 mm	Light grey Tahanga basalt
6954	Fragment of adze blade. Highly polished with sharp angles. Adze probably of relatively broad-bladed 4A form.	43 x 26 mm	Light grey Tahanga basalt
6955	Butt fragment of rectangular cross-sectioned adze. Shows flaking, hammer-dressing and polish. Haft polish over original patina at butt end.	50 x 33 mm	Dark grey Tahanga basalt
6957	Central part of highly polished adze of sub-rectangular cross-section. Narrows to missing butt.	102 x 57 mm	Greywacke (Waiheke Group?)
6958	Polished and lightly hammer-dressed fragment of a Type 4A adze.	85 x 34 mm	Green Waiheke Group greywacke
6959	Fragment of rounded margin of a highly polished adze.	63 x 23 mm	Light grey Tahanga basalt
6961	Butt end of strongly rectangular cross-sectioned adze. Polished over flake scars. Some haft polish on butt.	57 x 37 mm	Black metasomatised argillite from Mt Ears source
6963	Blade end of Type 4A adze. Highly polished over flake scars. Blade width 29 mm.	40 x 39 mm	Light grey Tahanga basalt
6964	Roughly finished butt end of oval cross-section. Strongly hammer-dressed — rare polish.	70 x 45 mm	Pale grey Tahanga basalt
6965	Part of small crude rough-out. Some original patina. Flaked only.	56 x 33 mm	Trachyte
6966	Blade end of broken rough-out. Slight polish at blade. Flake adze?	53 x 41 mm	Light grey Tahanga basalt
6969	Butt part of well-finished Type 2B adze. Some hammer-dressing at margins. The broken end is severely battered from use as hammer subsequent to the break.	105 x 68 mm	Green Waiheke Group greywacke

Table 1. Matatuahu site adze fragments *continued*.

6971	Butt fragment polished two sides, flaked and hammer-dressed on third side.	62 x 41 mm	Green Waiheke Group greywacke
6972	Water-rolled pebble minimally flaked, hammer-dressed and ground into adze shape. Some original patina. Blade severely battered.	80 x 47 mm	Green argillite
6973	Butt part of adze rough-out from flake adze. Some polish.	42 x 42 mm	Light grey Tahanga basalt
6974	Butt part of adze rough-out flaked and hammer-dressed. No polish.	76 x 35 mm	Mid-grey Tahanga basalt
6977	Butt part of very rounded cross-section adze. Well finished by hammer-dressing and polishing.	63 x 43 mm	Green Waiheke Group greywacke
6978	Central part of a sharp-edged rectangular cross-sectioned adze. Highly polished but considerable subsequent damage.	59 x 41 mm	Light grey Tahanga basalt
7172.3	Fragment of rectangular cross-sectioned adze. Polished over flake scars with some polish on break surface.	69 x 29 mm	Light grey Tahanga basalt
7324	Reworked fragment of broken adze — some polish.	71 x 46 mm	Tahanga basalt
7325	Part of large adze. Some original polish and hammerdressing.	108 x 68 mm	Light grey Tahanga basalt

The twin-lobed pendant is certainly an early form. Nelson serpentine was the preferred raw material for stone pendants of archaic style, and what is known of the provenance of the various examples argues strongly for their being early in the New Zealand sequence.

FILES

Forty files, file fragments and files in the process of manufacture are included in the Brambley Collection. All probably come from the Matatuahu site. Examples are shown in Figs. 30-51.

The files are made of sandstone, except one of green schistose greywacke (Fig.38) which is very similar to that of files in Palliser Bay assemblages (Leach 1979:72). The latter is also similar to Palliser Bay files in its slender form which may be a function of its strength compared with sandstone. Sandstone is the underlying rock of Awhitu Peninsula and was thus available locally.

Among the pieces are nine files in the process of being manufactured (for examples, Figs. 30-32). On a few of these can be seen the signs of the pecking out of a

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Figs. 30-51. Files, Matatuahu site. 30. AR7173.7. 31. AR7173.34. 32. AR7392. 33. AR7392. 34. AR7392. 35. AR7173.22. 36. AR7173.1. 37. AR7173.3. 38. AR7173.11. 39. AR7173.14. 40. AR7173.38. 41. AR7173.10. 42. AR7173.8. 43. AR7173.13. 44. AR7173.5. 45. AR7173.17. 46. AR7391. 47. AR7173.9. 48. AR7173.15. 49. AR7173.6. 50. AR7391. 51. AR7173.20.

groove and subsequent snapping along that groove by which the file was derived from the initial larger piece of rock.

The majority of files are *ca.* 15 mm in width, of flat oval cross-section, typical of the small files found in coastal sites of moa-hunter age throughout New Zealand. Other files are larger, with cross-sections of 35 mm or more (see for example, Fig.51). Large and small files of flat oval cross-section have been used for fine work with bone, such as in the fashioning of one-piece fishhooks, and perhaps wood. Sandstone, although a rapid abrasive, is comparatively coarse, hence the importation of schistose greywacke from what is undoubtedly a distant source. The latter is fine enough to give an excellent finish and strong enough to withstand much use.

Interestingly four files display fragments of *kokowai* (red ochre) on their pitted surfaces. The outstanding example is AR7173.20 (Fig.51), a large file with *kokowai* over both sides as well as at one end. Three small files also have traces of *kokowai.*

DRILLPOINTS

More than seventy drillpoints in the Brambley Collection are assumed all to derive from the Matatuahu site. Examples are shown in Figs. 52-68. In the case of one item (AR7145, Fig.61) the precise provenance is known, it having been found with a piece of whalebone (AR7287) at the west end of the beach. Drillpoints, like files, are evidence of boneworking, in all probability directed towards the manufacture of one-piece fishhooks, and also the drilling of stone and shell.

Most of the drillpoints are made of chert. The collection includes 58 items listed separately in the Archaeology Department catalogue (AR7108-7156, 7158-7165). Another twelve drillpoints are represented by fragmentary material in a bag of chert flakes (AR7166.1). A further four drillpoints are fashioned from broken pieces of adzes: of Tahanga basalt (AR7171.15 and 7172.20, Figs. 52, 53), and metasomatised argillite (AR7172.13 and 7167.17, Figs. 54, 55). Chert drillpoints are illustrated in Figs. 56-68.

HAMMERSTONES

Nineteen hammerstones are listed in the Jolly and Law catalogue of the Brambley Collection. A further four make a total of 23 described as such among material which came into the museum (AR7009-29, 7332-33). Twelve of the 23, however, can safely be rejected as hammerstones for lack of characteristic battered areas or facets. AR7009 was not found at the Matatuahu site and is treated below in the section on material from other than N46-47/17. The ten remaining items are said by Mrs Brambley to have come from the Matatuahu site.

The hammerstones fell into three groups: spherical stones substantially battered (i.e. used) all around (Figs.69-71), stones of flat oval cross-section which show use all or part-way around the rim (Figs.72-76) and flat pebbles used only around the narrow

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Figs. 69-78. Hammerstones, Matatuahu site. 69. AR7018. 70. AR7017. 71. AR7029. 72. AR7013. 73. AR7014. 74. AR7015. 75. AR7012. 76. AR7016. 77. AR7010. 78. AR7021.

Figs. 52-68. Drillpoints, Matatuahu site. 52. AR7171.15. 53. AR7172.20. 54. AR7172.13. 55. AR7167.17. 56. AR7125. 57. AR7129. 58. AR7126. 59. AR7119. 60. AR7154. 61. AR7145. 62. AR7109. 63. AR7122. 64. AR7120. 65. AR7161. 66. AR7135. 67. AR7124. 68. AR7123.

Table 2. Matatuahu site hammerstones.

Fig.	AR	Dimensions (mm)	Weight (g)	Raw material	Shape and use
69	7018	79 x 74	604	Pale chalcedonic chert	Virtually spherical — used almost all over
70	7017	69 x 49	297	Green chert	Flaked to shape then used all over except area of brown cortex
71	7029	46 x 44	126	Green chert (c.f. AR7017)	Small faceted hammerstone used over entire surface
72	7013	73 x 47	338	Grey-brown chert	Water-rolled pebble is used at two ends of the long circumference
73	7014	62 x 42	177	Green Waiheke Group greywacke	Hammerstone made by flaking — lightly used around circumference
74	7015	63 x 29	145	Fine-grained green chalcedonic chert	A flat stone has been made with the help of natural cleavages in the rock — used around the full circumference
75	7012	66 x 55	306	Chert — pale brown with red patina	Faceted pebble is much used around the full circumference but not on the two flat sides
76	7016	92 x 85 49 deep	567	Andesite	A flat water-rolled stone is battered all around the circumference
77	7010	89 x 76 20 deep	186	Basalt	Spall from a water-rolled boulder is battered around the narrow perimeter
78	7021	69 x 59 24 deep	143	Greywacke	Flat water-rolled pebble used at two ends

rim (Figs.77-78). Table 2 lists the ten items and their salient characteristics. Raw materials are chert, basalt, greywacke and andesite, ranging from very hard in the case of chalcedonic cherts to comparatively soft basalt and andesite.

From the evidence of other stone material on the site the Matatuahu hammerstones would have been used for flaking stone, for hammer-dressing items such as adzes and for pecking out areas such as fishing sinker tying grooves. The larger heavy stones are typical flaking hammerstones, such as AR7018 (Fig.69) which was found with a large chert core (AR7351; see Fig.104). Narrow-rimmed items, for example AR7010 and AR7021 (Figs.77,78), may have been used for work such as preparing grooves in sinkers. Hammerstones like files and drillpoints are tools to make tools and as such are evidence of manufacturing taking place at the site.

HOANGA

Only two *hoanga*, or grindstones, in the collection of approximately twenty pieces collected and catalogued as such, are securely located to the Matatuahu site. It is, nonetheless, likely that many of the remainder also come from the site but that their exact provenance is now lost. Illustrations are with unprovenanced material (Figs. 184-194).

A massive sandstone block 400 x 170 x 80 mm (AR6989; Fig. 186) was found on the beach at the west end of the site. The two largest sides are slighly concave as a result of use as a grindstone. The second item is more problematic. AR6990 (Fig.185) is a block of coarse crystalline sandstone, with grooves and some 'dishing' which may be the result of grinding and sharpening stone tools. It was found on the beach near the 1960 Brambley excavation.

SINKERS

Of the very large number of stone fishing sinkers in the Brambley Collection only three can be located to the Matatuahu site with any certainty. Mrs Brambley recalls that no sinkers were actually excavated from the site but that all were found along the shore, mostly from Wattle Bay (Awhitu) to Tarataua (see Fig.2). Matatuahu sinkers are illustrated with unprovenanced material (Figs.154-173), where the topic is covered in more detail.

AR7055 (Fig.169) was washed out at the west end of the site. It is made of a vesicular basalt by means only of four very minimal notches hammered at opposite margins of the slightly flat cobble. Two small sinkers of consolidated iron sand (AR7058 and AR7067, Fig.166) also come from the beach at the west end of the site. Both are elongate and designed to hang down their long axes.

PUMICE

Approximately 35 pieces of pumice are included in the Brambley Collection. All are presumed to come from the Matatuahu site. (An exception is AR7234 from Rangatira Point, Lake Taupo; see Appendix 1). The great majority display no sign of having been used or worked, their even rounded form most likely resulting from natural abrasion. Artefactual pieces are shown in Figs. 79-91.

Fig. 79 shows a piece of pumice with a large groove indicating use for polishing a wood shaft (AR7230). Another piece showing many polishing facets and grooves is AR7232 (Fig.80). At least three pieces of elongated 'file' shape may have been used for polishing or abrading (AR7231, Fig.81; AR7246, Fig.82; AR7238, Fig.85). Other pieces of similar form are less easily identified as tools. Two pieces have curved polishing facets (AR7239, Fig.83; AR7240, Fig.84), while two more are thin with flat polishing surfaces, one of which also displays signs of use on its sharp edge (AR7237, Fig.86; and AR7236, Fig.87).

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Figs. 79-91. Pumice, Matatuahu site. 79. AR7230. 80. AR7232. 81. AR7231. 82. AR7246. 83. AR7239. 84. AR7240. 85. AR7238. 86. AR7237. 87. AR7236. 88. AR7290. 89. AR7288-89. 90 AR7291. 91. AR7276.

A group of five small pieces of pumice found adjacent to the University excavation area show signs of having been worked, including shaping and drilling (AR7288-7291, 7276; Figs. 88-91). Other pumice items are tools used in manufacturing, these pieces are themselves the object of manufacture. Just what the purpose was is open to question: two fitting pieces (Fig.89) have been shaped and drilled in the manner of a one-piece fishhook tab.

KOKOWAI

Approximately 35 pieces of *kokowai*, or red ochre, are said by Mrs Brambley to have come from the Matatuahu site (AR7252-7257). They weigh a total of 1580 g with one large piece of coarse sandy material making up 961 g of this. *Kokowai* is available in the Waitakere Ranges north of the Manukau Harbour entrance.

Kokowai from Matatuahu ranges from coarse-grained soft sandstone to very fine-grained compact lumps of clay-like consistency. Other material has the texture and orange-red colour of brick.

Two pieces have evidence of use. A very fine-grained fragment of deep red colour, broken off a larger piece, has grooves 4-6 mm wide on two faces indicating use for rubbing on an edge of some kind (AR7255). The second piece, again only *ca.* 40 mm in maximum dimension, is strongly dished on one face (AR7253). Traces of *kokowai* on a quarter of the obsidian flakes and on some files recovered from the Matatuahu site provide further evidence of the use of this important decorative material.

MISCELLANEOUS STONE MATERIAL

Stone flakes in the Brambley Collection are all attributed to the 1960 excavations. The material includes waste flakes and fragments and cutting and scraping tools. Stone material includes obsidian, chert, basalt, metasomatised argillite, greywacke, sandstone, nephrite and other rock types.

Obsidian

Several hundred obsidian flakes and fragments include green and grey material. Almost all are of good quality obsidian, with some spherulitic material especially of grey colour. There is limited evidence of patination to suggest large blocks of obsidian. A high proportion show signs of edge damage as a result of use as cutting, scraping and finishing tools. Approximately one-quarter of the total have *kokowai* remains adhering to them, to indicate use in working or finishing items with *kokowai* decoration.

Green obsidian is much the most abundant: approximately 450 flakes and core fragments weigh a total of 2585.5 g. Included are 98 flakes (439.5 g) with *kokowai* remains adhering to them. Some very large pieces make up much of the total weight, six total 819 g. Among the latter are two core pieces with water rolled surfaces. One

piece appears to have been fashioned from a prepared block as a 'blade'. It measures 75 x 25 mm and bears clear signs of earlier 'blades' having been struck from the 'outer' surface of the prepared core.

Grey obsidian totals approximately 130 pieces, weighing 596 g. Thirty pieces (179 g) carry traces of *kokowai*. The material includes obsidian with spherulites — of a poorer quality than other stone and frequently retaining some cortex, showing that it is collected from stream beds and gravel deposits rather than from *in situ* flows. Other grey obsidian is very pale milky grey and yet another variety is banded. One piece has a cortex with pink striations. Flakes of grey obsidian are commonly smaller than those of green material.

One fragment of obsidian has the surface colours black (grey?) and brick red Large grey spherulites are present. The material is of comparatively poor quality and is clearly waste, having no useful edge or sign of wear.

Chert

Approximately 650 pieces of chert weigh a total of *ca.* 17.27 kg. Included are several core blocks, large flakes (many with edge damage), drillpoints, and small used flakes, waste flakes and pieces. A range of flakes and cores is illustrated in Figs. 92-106.

The collection includes cherts of a very wide variety of colours and qualities. There is superb quality chert of fine even grain, in opaque and translucent white, grey, and brown. High quality pale chalcedonic cherts, red siliceous sinter such as that from Kuaotunu Peninsula, Coromandel (for example, AR7166.14; Fig.100), and poorer quality petrified wood and chert tending to quartz are all represented. Poorer quality material comes in a wide range of colours. The immense range of cherts illustrates both the extensive 'catchment' area of the Matatuahu site and a very considerable knowledge of available resources on the part of its inhabitants.

Several large blocks illustrate the nature of chert usage. Such 'cores' would be brought to the settlement at the mouth of the Manukau Harbour where sharp-edged flakes would be struck off as required. AR7352 (Fig.105) is a massive (6.8 kg) block of stone extensively worked for unusually large flakes of very even quality. Mrs Brambley recalls that this item came from within the early 1960 excavation area. Areas of cortex remain on both sides. The material is an orange-brown colour with faint black marking throughout. AR7351 (Fig.104) is a 1581 g core of fine grained creamy-white chert —comparatively intractable material from which to strike useful flakes. It was found in association with a hammerstone (AR7018) at the Matatuahu site. Much better quality is AR7166.21 (Fig.106). This item weighs 931 g and is coloured grey and black in fine bands. Despite extensive use it retains some areas of original patina on most sides. The smallest of the illustrated chert cores (263 g) is AR7166.14 (Fig.100). In this case the material is of pink, cream and yellow colour and is strongly vesicular — the overall appearance is reminiscent of the siliceous sinter sourced to Kuaotunu Peninsula, Coromandel. The rock has been difficult to deal with because of a tough and uneven texture, but nonetheless has extensive signs of working to remove mostly small flakes.

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Figs. 92-106. Chert flakes and cores showing a range of raw materials, Matatuahu site. 92. AR7166.25. 93. AR7166.5. 94. AR7166.2. 95. AR7166.22. 96. AR7166.27. 97. AR7166.24. 98. AR7166.19. 99. AR7166.16. 100. AR7166.14. 101. AR7166.12. 102. AR7166.26. 103. AR7166.18. 104. AR7351. 105. AR7352. 106. AR7166.21.

Tahanga basalt

In addition to the complete or part adzes made from Tahanga basalt there is a small number of flakes and fragments. The material includes as many as six large 'primary' flakes struck from a block in the course of adze manufacture. These indicate that at least some Tahanga basalt was brought to the Matatuahu site unworked or only partly worked for subsequent fashioning into adzes. Some of the smaller flakes have polished surfaces to show that they were struck off adzes.

Other basalt

Less than ten struck flakes and upwards of 100 small chips and fragments are included among poor quality basalt material. It is likely this material comes from the north side of the Manukau Harbour entrance where the notable headland landscape feature, Paratutae, is made of basalt. While the struck flakes and rare poor quality rough-out items indicate some use of this material in adze making, it seems likely that much of it came to the site as hangi stones.

Metasomatised argillite

A few small flakes of metasomatised argillite may be added to the various complete or part adzes and chisels which have come from the Nelson-D'Urville Island 'mineral belt'. Included in the waste material are at least eight flakes of characteristic argillite from the Ohana source at the south end of D'Urville Island. Three pieces of high quality black stone come from the Mt Ears source, also on D'Urville Island.

It is likely that all, or almost all, these small flakes come from damaged adzes. In the case of two of the items of Ohana argillite this is evident from hammer-dressed surfaces. The black Mt Ears pieces all have areas of polish. Two other fragments from broken metasomatised argillite adzes have been transformed into drillpoints (one Mt Ears material, AR7172.13, Fig.54; and one possibly of Ohana stone, AR7167.17, Fig.55). Another fragment of Ohana argillite has received some minimal polishing to form a tiny chisel (AR7167.6). More substantial pieces of broken adzes are treated above. The high level of re-use of broken adzes of metasomatised argillite demonstrates the great value put on this material.

Waiheke Group greywacke

Approximately twenty fragments of the characteristic high quality Waiheke Group (Schofield 1967) greywacke are included among waste stone material from the Matatuahu site. At least ten are from broken adzes, demonstrated by polished surfaces. The remainder include small pieces which may be from broken adzes, and one large piece (AR7337) which is clearly too large to be part of a former tool, and thus demonstrates at least some transportation of raw material to the site.

Nephrite

Rare nephrite (pounamu) items and fragments in the Brambley Collection include some which come from the Matatuahu site. Eight tiny fragments of pale green (almost inanga variety) nephrite (AR7179) are probably those remaining of ten which are reported as having been found during the Brambley excavations of early 1960 (see Brambley 1966:120). They all come from one piece of stone, five of the fragments showing signs of having been cut. A 22 mm long, 12 mm wide blade fragment of a nephrite chisel (AR7174) is also said to have come from the Matatuahu site.

Other stone material

In addition to the raw materials listed above, a wide range of rock types, less important in tool making, is represented in the Matatuahu assemblage. Included are a variety of greywackes and unaltered argillites, trachyte and mudstones. At least some of these materials were brought from a distance to the site, and must therefore have had a value not always apparent from remaining fragments.

BONE

Bone from the Matatuahu site can be attributed to the limited excavations of January-February 1960 and November 1960, and the Trower-Jolly material of 1965. Moa and dog bone is the most abundant, with some sea mammal and fish making up the remainder.

Moa

Moa bone is very rare in sites of the Auckland region so that material from the Matatuahu site is of some importance. Approximately 800 g of bone has been identified in the Brambley Collection.

Table 3 shows moa represented at Matatuahu to belong to only three species: *Dinornis novaezealandiae, D. struthoides* and *Pachyornis mappini*. All identified material is of the large leg bones, femur and tibiotarsus. The only substantial bone is a 340 mm long shaft of a *D. novaezealandiae* right tibiotarsus (AR7272). All else is very fragmentary material.

Bone from the Matatuahu site does not appear to represent the killing and butchery of moa. It has nothing of the fresh character of moa bone such as from another west coast North Island site, Kaupokonui (N128/3B) in south Taranaki. The Matatuahu bone was probably brought to the site as sub-fossil bone for manufacturing into fishhooks and other items. The argument for this is strengthened by the only bones present being the femur and tibiotarsus, the very bones which would have been selected for industrial purposes.

Table 3. Matatuahu site moa bone.

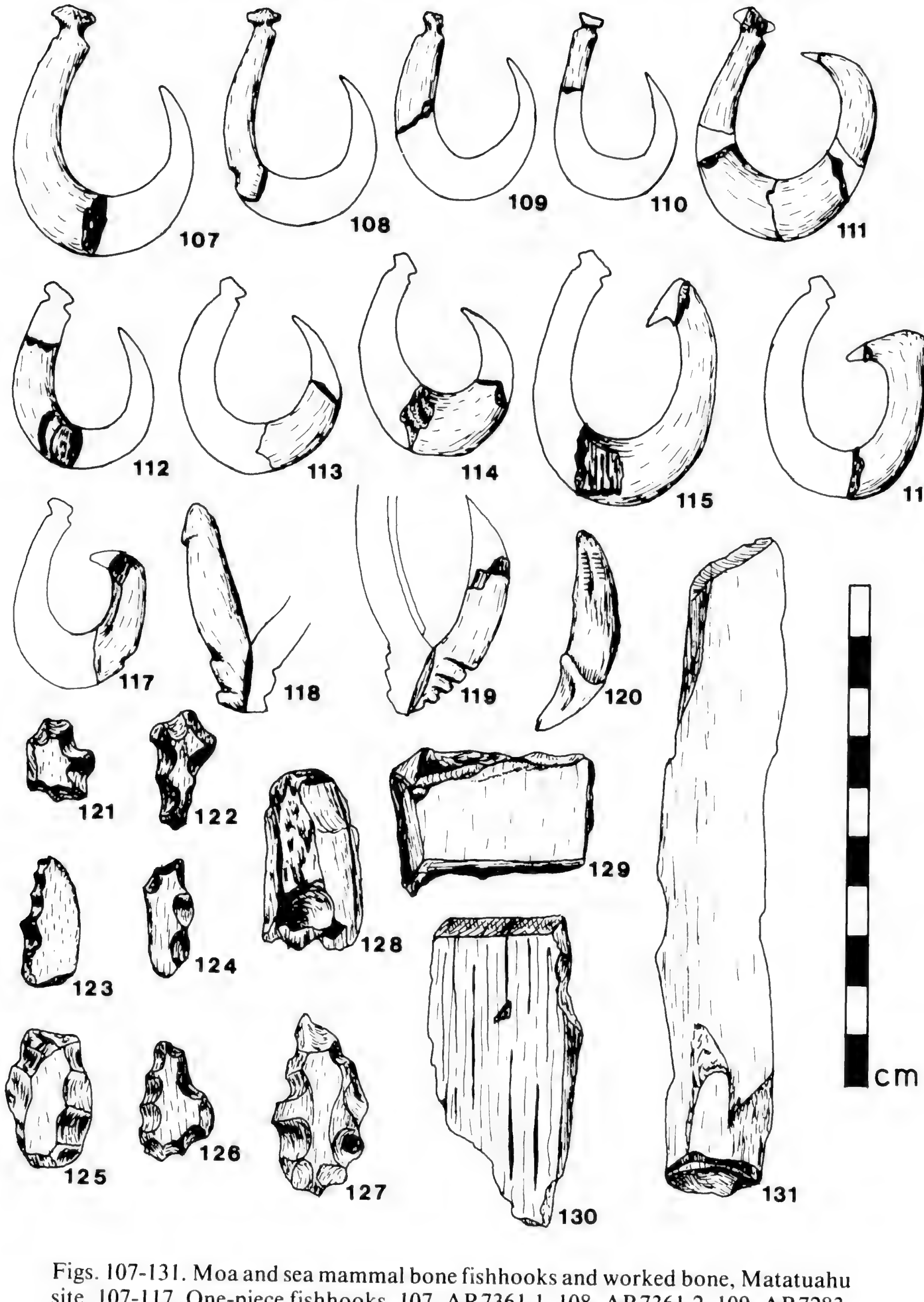
Cat. no.	Description
Brambley Collection	
AR7271	Tibiotarsus fragment — *Dinornis*, at least *D. novaezealandiae* size (Fig.131)
AR7272	Right tibiotarsus — *D. novaezealandiae* (approaching *giganteus* size)
AR7295	Femur? fragment — medium sized moa
AR7301	Fragment — medium to large moa (*Dinornis*?)
AR7302	Fragment — medium to large moa (*Dinornis*?)
AR7303	Fragment — medium to large moa (*Dinornis*?)
AR7309	Fragment — medium to large moa (*Dinornis*?)
AR7316	Fragment — medium to large moa (*Dinornis*?)
AR7364	Femur fragment — medium to large moa
November 1960 excavation	
AU402a	Tibiotarsus fragment — *Dinornis*, at least *D. novaezealandiae* size
AU402b	Tibiotarsus fragment — *Dinornis*, at least *D. novaezealandiae* size
AU402c	Tibiotarsus fragment — *Dinornis*, at least *D. novaezealandiae* size
AU402d	Distal end of right tibiotarsus — *D. struthoides*
AU346	Shaft fragment left tibiotarsus — *D. novaezealandiae* (assumed to originate from November 1960 excavation)
Trower and Jolly collection	
AR7445	Right femur fragment *Pachyornis mappini*
AR7445	Shaft fragment femur or tibiotarsus — probably *P. mappini*

One *Dinornis* tibiotarsus fragment (AR7271, Fig.131) has been reduced down the sides and cut at one end, while a number of other fragments have been prepared to shape, including AR7273 (Fig.128) which has been drilled. At least some of the one-piece fishhook fragments are of moa bone (including AR7361.1, Fig.107).

Dog

The greater part of dog bone from the Matatuahu site was collected by the Brambleys and R.G.W. Jolly in 1960, coming to the museum via the University collections. Other bone came to the museum in 1974 and 1981, and in the small Trower and Jolly collection of 1965. The material was not collected systematically; much of it is in a very fragmentary state.

The bone consists largely of head and limb bone fragments. Four intact or substantially intact mandibles and a great deal of more fragmentary material indicate



Figs. 107-131. Moa and sea mammal bone fishhooks and worked bone, Matatuahu site. 107-117. One-piece fishhooks. 107. AR7361.1. 108. AR7361.2. 109. AR7283. 110. AR7264. 111. AR7269, AR7266, AR7265. 112. AR7385. 113. AR7275. 114. AR7268. 115. AR7362.1. 116. AR7362.2. 117. AR7358. 118-120. Two-piece fishhooks. 118. AR7261. 119. AR7360. 120. AR7267. 121-127. Waste from one-piece fishhook manufacture. 121. AR7286. 122. AR7285. 123. AR7281. 124. AR7384. 125. AR7280. 126 AR7358. 127. AR7270. 128-131. Worked pieces of bone. 128. AR7273. 129. AR7366. 130. AR7277. 131. AR7271.

as many as ten right and four left mandibles. Maxilla material is even more fragmentary. There are also some loose teeth. Numerous small skull fragments include frontal and occipital material. Three left humeri are represented by small pieces, all of which display signs of having been chewed by dogs. Two of the three left and two right ulna fragments also have apparently been chewed. The radius is represented only by some very fragmentary material. One right femur is heavily chewed by dogs. Three tibia fragments again include two which have been chewed by dogs. Eight or more metapodials complete the limb bones. Other bone consists of at least two vertebral pieces, a pelvic fragment and some fragmentary rib pieces.

There is little that can be said about the dog bone. Much of the bone suggests larger animals than were present at far north sites of similar age (M. Taylor, pers. comm.). One metapodial was from a juvenile animal. The predominance of skull and limb bones may have something to say about butchering and consumption patterns or may relate only to differential survival or collector interest.

Sea mammal

All seal bone probably comes from the New Zealand fur seal (*Arctocephalus forsteri*), although sea lion (*Phocarctos hookeri*) could not be ruled out in some cases. Among seal bone is a substantial piece of right radius, the proximal end of a left radius, a left ulna fragment, two canines and some other teeth, and fragmentary material. A massive piece of bone (AR7287) from a medium sized (13-17 m) whale is said by Mrs Brambley to have come from the west end of the Matatuahu site.

Among worked and artefactual material are several one-piece fishhook fragments of sea mammal bone (AR7265-6 and AR7269, Fig.111; AR7268, Fig.114; and AR7275, Fig.113). The worked pieces AR7277 and AR7366 (Figs.130,129) are also sea mammal bone.

Fish

Approximately 60 g of fish bones is almost all snapper (*Chrysophrys auratus*) at least some of which is dog chewed. Jaws are strongly represented. A shark tooth and single trevally (*Caranx georgianus*) bone make up the remainder.

Pig

A single fragment of a pig mandible only demonstrates the shortcomings of surface collected material.

BONE ARTEFACTS

Bone artefacts are confined largely to fragments of one-piece fishhooks and waste pieces from their manufacture (Figs.107-117,121-130). There are also rare pieces of

two-piece fishhooks (Figs.118-120) and some worked bone for which the purpose is not entirely clear (for example Fig.131). An especially important item is a harpoon point (Fig.132). Sea mammal and moa bone were both used although most bone is too fragmentary and too weathered for proper identification.

One-piece fishhooks follow typical early forms. Fig.111 depicts a reconstructed hook made from four fragments (two fitting) of markedly similar bone which may have belonged to one hook. The bone is identified as sea mammal. Three parts of two-piece bait hooks (Figs.118-120) must be assumed to have come from the Matatuahu site for lack of alternative information.

Pieces of worked bone include sawn fishhook blanks (Figs.129,130) and at least four other fragments of bone which have been partly prepared for future use. In some cases working has involved only the rough breaking out of usable flat pieces of bone. Fig.131 (AR7271) depicts a 130 mm long tibiotarsus fragment of *Dinornis* size which has been flaked to shape down both sides and sawn then snapped at one end. The 340 mm long piece of a *Dinornis novaezealandiae* tibiotarsus is part of this assemblage of industrial moa bone.

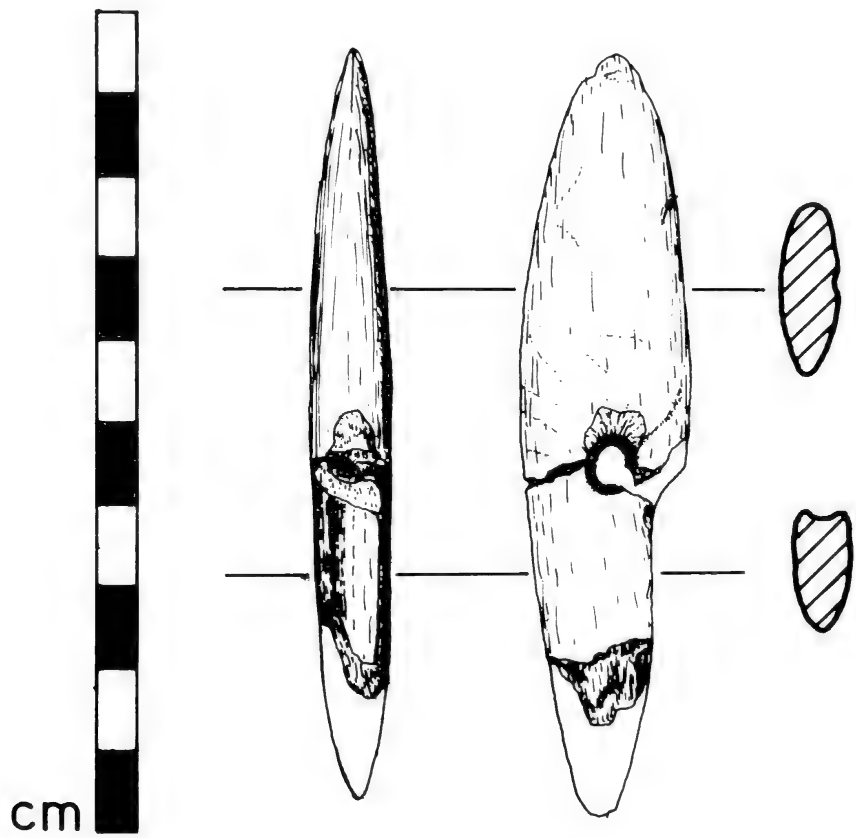


Fig. 132. Bone harpoon point, Matatuahu site. AR7359.

Harpoon

An incomplete harpoon point (AR7359, Fig.132) was found in early 1960 during the Brambley excavations. It is made of moa or sea mammal bone and is 82 mm long. A single perforation (now broken out), with a shallow groove to the rear of it, provides for attachment to the harpoon shaft. Skinner (1974:144) depicts this harpoon point and places it in his Variety 6, "harpoon head without barb and grooved". He pictures a similar example from the Dunedin district. It is clear that harpoon points of this style belong to the earliest period of New Zealand history, notwithstanding Duff's (1956:229) reference to eighteenth century associations of a Banks Peninsula harpoon point and the well-known Oruarangi examples which must be late (Skinner 1974:144-145). The parallel between New Zealand and other eastern Polynesian harpoon points has been drawn often enough — the Matatuahu point is a key item in dating the site at an early period of settlement in the greater Auckland region.

MATERIAL FROM OTHER THAN THE MATATUAHU SITE AND UNPROVENANCED MATERIAL

Material in the Brambley Collection from other than the Matatuahu site is generally more selective than the Matatuahu assemblage. It comprises mostly adzes, fishing sinkers, hammerstones, grindstones and a few items of European manufacture. Absent are artefacts made of bone, sandstone files, drillpoints and waste and flake stone material.

A number of individual items and groups of items have some provenance information. It must be remembered, however, that only positively located material is included above in the Matatuahu assemblage, and that many of the items introduced below may also have come from the N46-47/17 site.

ADZES AND CHISELS

In the Brambley Collection adzes from other than the Matatuahu site are dominated by the simple, and probably late, Duff (1956:163-168) Type 2B form. Rare items of distinctly archaic character it is tempting to add to the early assemblage for the Awhitu district even when a location other than the Matatuahu site is given.

Adzes of rectangular or sub-rectangular form

Duff's (1956:163-168) Type 2B form is the least satisfactory of his adze types, reflecting as it does the comparative rarity of the form among South Island assemblages with which he was most familiar. He describes his Type 2B as, "... the type of medium-sized adzes of rounded rectangular section, without grip" (Duff 1956:164). In North Island assemblages these adzes can be very abundant and may take a variety of forms within the overall type. In the Brambley Collection a total of 23 adzes from other than the Matatuahu site may be grouped under the general 2B form. A range of

forms is shown in Figs.133-139; the remainder, which are not illustrated are listed in Table 4.

Fig.133 depicts a highly polished adze of very rounded cross-section (AR6896). It is made of dark green material which may possibly be Waiheke Group greywacke. Distinctive half-polish on the butt indicates heavy usage. The length is 147 mm; the width of the now broken blade may have been *ca.* 60 mm. AR6913 (Fig.134) also has a very rounded cross-section, in this case reduced sharply to the butt end. The stone is a green greywacke, also probably of Waiheke Group material. The length is 124 mm and blade width, 50 mm.

Figs. 135 and 136 show two small adzes which were found together on the beach below Tipitai homestead, and which were the first adzes found by the Brambley family. The chisel AR6916 (see below) was found close by. AR6883 (Fig.135) is a highly polished adze of unremarkable Type 2B form. The raw material is black Mt Ears (D'Urville Island) metasomatised argillite. A high degree of polish on the butt relates to hafting of the adze in the socket of a two-piece helve. It is 92 mm long with a 48 mm wide blade. AR6885 (Fig. 136) is made of a green indurated argillite (which is interestingly similar to that of the Purangi source in Taranaki; Keyes 1971). This adze also has a high degree of overall polish, except for a slight hammer-dressed reduction part way down the front margins. Haft polish is apparent on the back and at the butt end. The length is 90 mm and blade width, 41 mm.

Several adzes are of the style illustrated in Fig.137. This broad form with a steep and well-defined bevel is often made of Waiheke Group greywacke in the Auckland region, as indeed is the example shown, AR6887. Other Brambley Collection adzes of this style made of the same material are AR6890 and AR6893 of which details are given in Table 4. AR6887 was found on the beach half-way between Tipitai and Awhitu. It is polished overall with its short steep bevel rising from a severely blunted blade — so blunt in fact that it would certainly not cut wood. The length is 138 mm and blade width, 69 mm.

AR6962 (Fig.138) is a reworked piece from a larger broken adze, possibly of Type 1A form. On one side there is a polished surface with *ca.* 10 mm of hammer-dressed grip reduction at one end. The other faces are all flaked as the craftsman has attempted to fashion a new adze from the broken fragment. The raw material is mid-grey metasomatised argillite probably from a Nelson source.

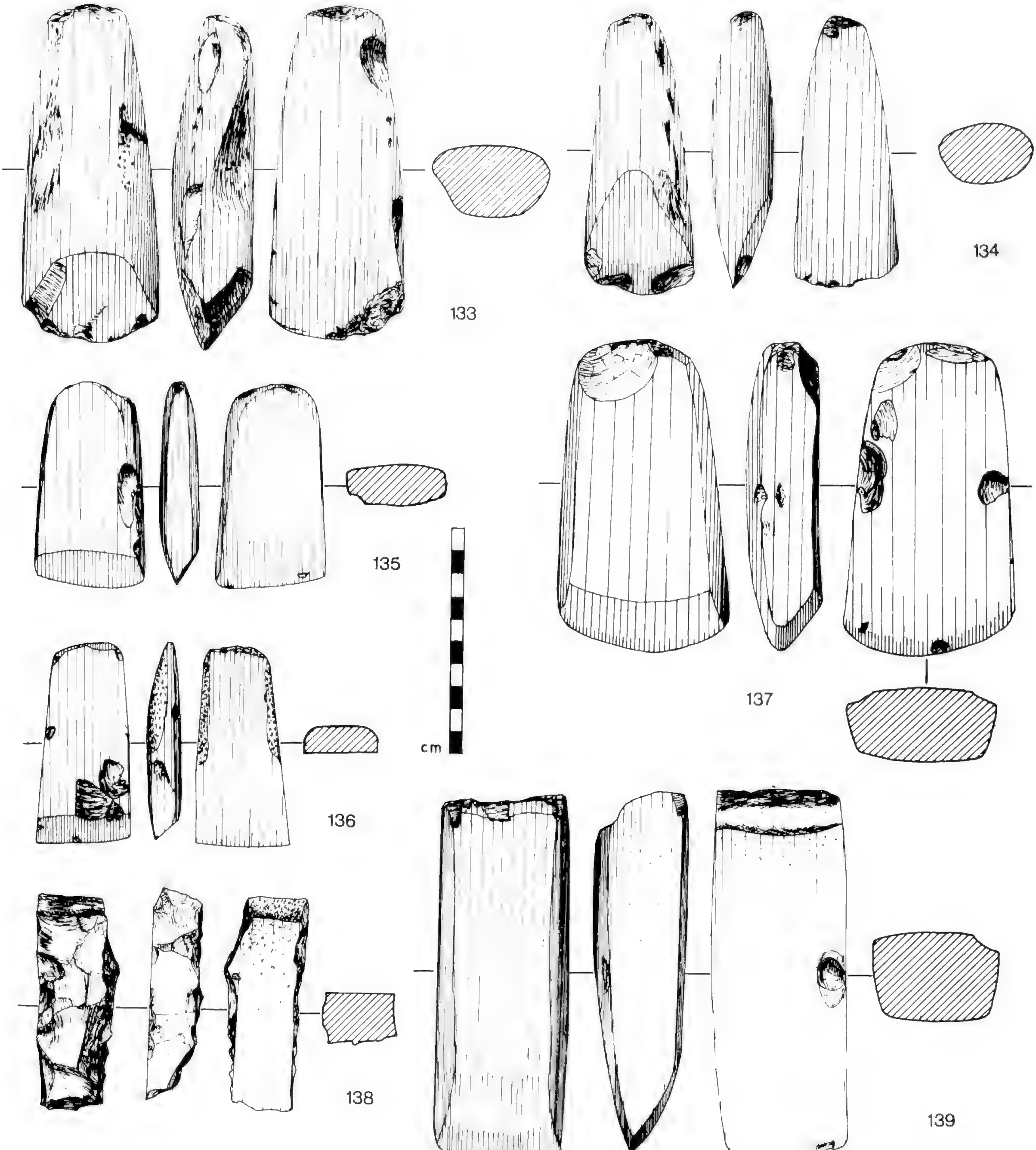
Another adze which has been re-used following breakage is AR6915 (Fig.139). Made of a relatively coarse green Waiheke Group greywacke, this highly polished adze of close to square cross-section has had an unknown amount broken off the butt end. A minimal amount of regrinding smooths off the front and rear edges of the break to allow re-use. The length of the surviving piece is 164 mm and the blade width is 52 mm.

A further 16 Type 2B adzes are listed in Table 4. Information regarding the provenance of some of these is given by Mrs Brambley. AR6889 was found on the beach below the lighthouse at Manukau South Head. AR6894 is said to have been

Table 4. Brambley Collection Type 2B adzes, from other than the Matatuahu site *.

AR	Condition	Finish	Length (mm)	Width at blade (mm)	Raw material
6886	Complete	All over polish	87	45	Waiheke Group greywacke
6888	Broken blade	All over polish — some original patina	*ca.* 105	*ca.* 42	Waiheke Group greywacke
6889	Complete — sand blasted	All over polish	93	44	Waiheke Group greywacke
6890	Complete	All over polish	127	70	Waiheke Group greywacke
6892	Broken blade	All over polish	*ca* 122	*ca.* 49	Waiheke Group greywacke
6893	Complete	All over polish	96	44	Waiheke Group greywacke
6894	Complete	All over polish	129	49	Waiheke Group greywacke
6895	Complete	All over polish	73	38	Black (Tahanga?) basalt
6900	Broken blade	All over polish	76	*ca.* 43	Waiheke Group greywacke
6904	Complete	All over polish except deep flake scares	82	39	Volcanic breccia
6906	Battered blade	All over polish — lateral hammer-dressing	119	*ca.* 57	Waiheke Group greywacke
6912	Complete	All over polish — minimal hammer-dressing at sides and butt	163	52	Waiheke Group greywacke
6926	Broken — being reworked	Some polish and hammer-dressing from broken adze	71	*ca.* 44	Tahanga basalt
6931	Complete — remodelled from part of larger adze	All over polish except flake scars	69	31	Black Tahanga basalt
6948	Complete except for slightly damaged blade	All over polish except deep flake scar at front	86	45	Pale grey Tahanga basalt
7446	Complete except for two small damage flakes off blade	All over polish	32	20	Metasomatised argillite — Ohana source

* Not illustrated in Figs.133-139.



Figs. 133-139. Adzes rectangular and sub-rectangular form, Manukau South Head district. 133. AR6896. 134. AR6913. 135. AR6883. 136. AR6885. 137. AR6887. 138. AR6962. 139. AR6915.

found in the cowyard at Tipitai, and AR6895 was found in the garden at Tipitai — apparently with paint on it, indicating that it had been discarded by an earlier finder.

Triangular cross-sectioned adzes

Two important triangular cross-sectioned adzes of early form probably relate in general to the Matatuahu assemblage. Both belong to the untanged Duff (1956:170-176) Type 3B.

AR6942 (Fig.140) was found on the shore below the lighthouse, 1-2 km west of the Matatuahu site. It is made of grey Tahanga basalt on which original patina is visible at the butt end. The adze is superbly flaked, with hammer-dressing confined to a little smoothing of the sharp side edges. It is unfinished; no polish is apparent. The length is 267 mm, and the blade width, 97 mm.

A smaller Type 3B adze (AR6921, Fig. 141) is almost identical in form and treatment. Again it is rendered in Tahanga basalt, this time however, of the black variety. This adze, too, is superbly crafted. Like AR6942 it has overall flaking (although here there is the faintest polish on the bevel) and again the sharp sides are reduced by minimal hammer-dressing. Natural patina at the butt end is similar to the larger adze. AR6921 is 217.5 mm long with a blade 66 mm wide.

Other triangular cross-section adzes or fragments may be more briefly dealt with. Fig.144 shows a small adze, crudely flaked from a coarse-grained volcanic rock (AR6933). It is polished on the front and bevel only. The blade is badly battered. The remaining length is 92 mm, with a blade width *ca.* 37 mm. AR6979 (Fig. 142) is the 86 mm long butt end of a triangular sectioned rough-out in pale grey Tahanga basalt. AR6960 (Fig.143) is again a butt only (76 mm long), and like AR6979 is of relatively deep triangular form. Again it is roughed out only, this time of black Tahanga basalt.

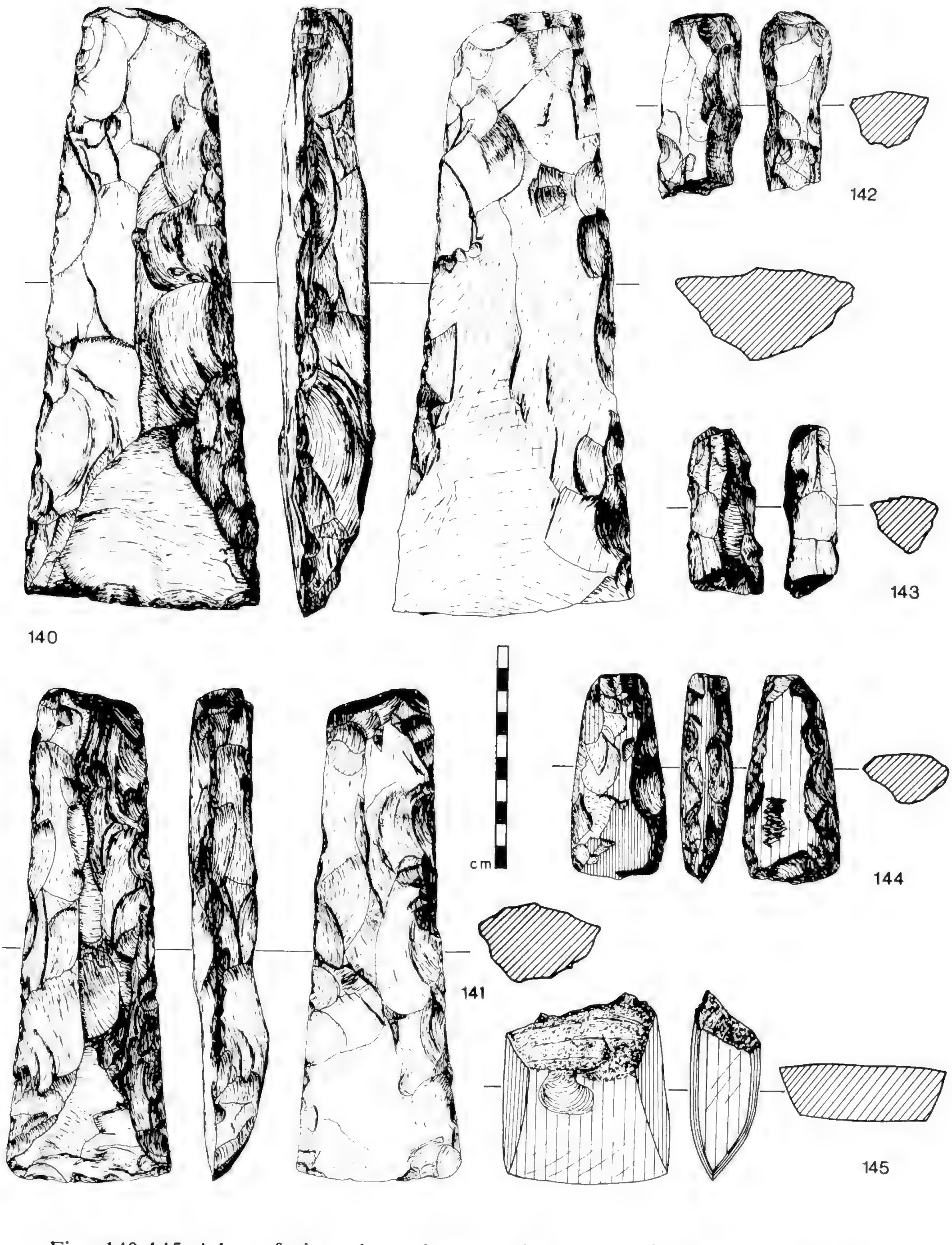
Rectangular adze of early form

The 72 mm wide blade of a well finished rectangular adze, possibly of Duff Type 2A form, is shown in Fig.145 (AR6934). It is made of high quality green Waiheke Group greywacke. There is no given provenance.

'Hogback' adzes

Duff's (1956:178-180) Type 4A, 'hogback' adze is very characteristic of the early phase of Polynesian settlement in New Zealand. A butt fragment (Fig.147) was recovered from the Brambley excavation of early 1960, but the only complete example of comparable size does not come from the Matatuahu site.

AR6943 (Fig.146) Mrs Brambley could only recall having come from ". . . somewhere on Tipitai farm." This adze has suffered very minor damage at the blade but is otherwise complete. Like the Matatuahu fragment (AR6930, Fig. 147) it is made of fine-grained green Waiheke Group greywacke. It is well finished with a reduced butt



Figs. 140-145. Adzes of triangular and rectangular cross-section, Manukau South Head district. 140-144. Triangular cross-sectioned adzes. 140. AR6942. 141. AR6921. 142. AR6979. 143. AR6960. 144. AR6933. 145. Rectangular cross-sectioned adze blade. AR6934.

and polish concentrated towards the working end. The length is 269 mm, with the narrow chisel blade now broken off being estimated at *ca.* 15 mm width.

Fig. 149 depicts a superb Duff Type 4A adze (AR6916) which Mrs Brambley recalls was found on the beach below the house at Tipitai. The raw material may be a basalt from the north side of Raglan (Whaingaroa) Harbour (D. Bonica, pers. comm.). It is the only item in the Brambley Collection of this characteristic material which is abundant in occupation sites found on the deflating dunes of the north head of Raglan Harbour, and well represented in the Keith Bird Collection, Horea, Raglan North Head. The flat butt end shows the original patina of the rock, giving clues as to the method of manufacture. AR6916 has been polished back to the reduced butt end over skilful flaking. The length is 160 mm and the width of the strongly curved, hollow-ground blade is 19 mm.

The highly polished blade fragment of a Type 4A adze (AR6935) is shown in Fig.148. The Tahanga basalt adze may have been *ca.* 250 mm long to judge from the surviving piece. The blade is 18 mm wide.

Flake adzes

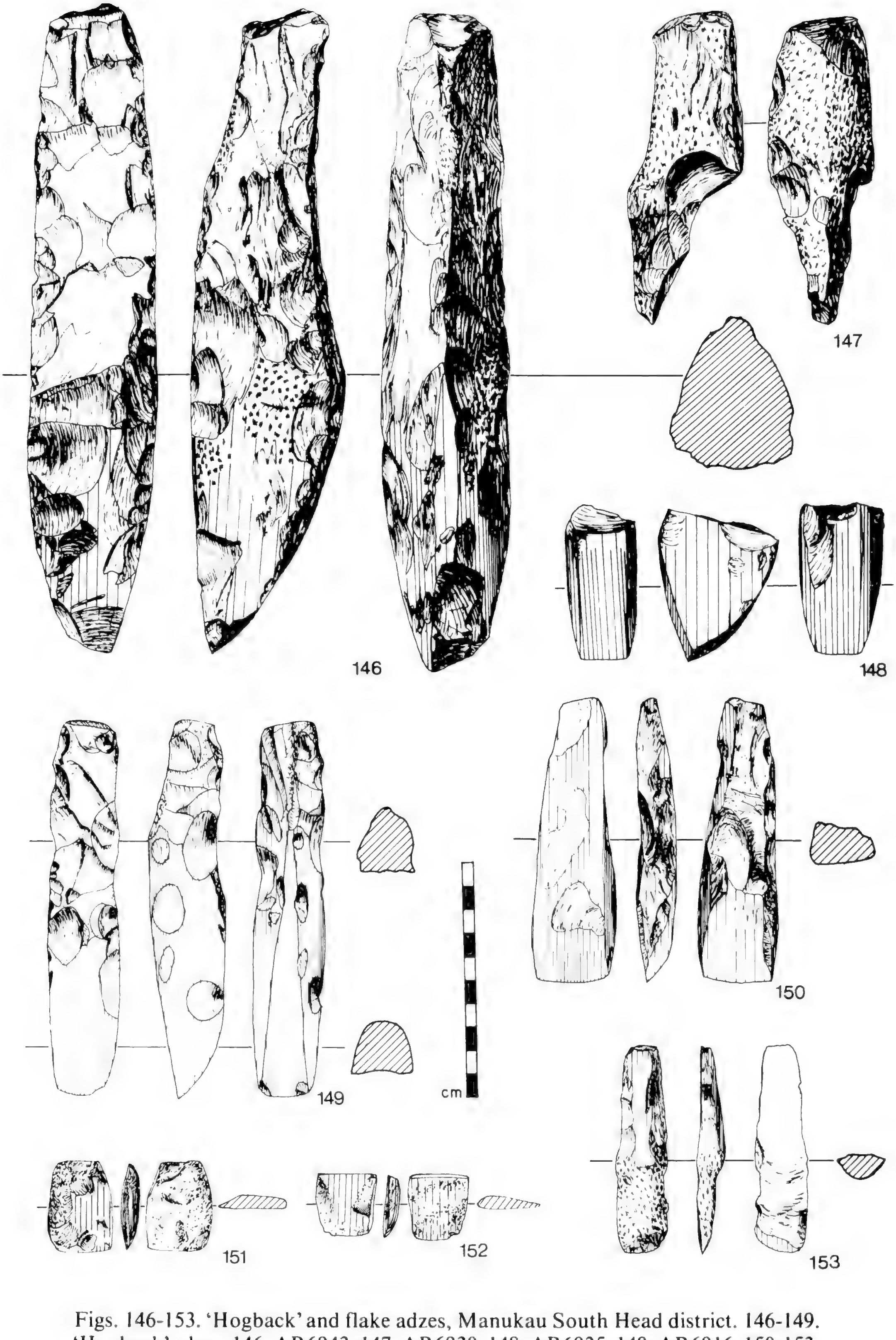
Characteristically flake adzes display some lateral reduction of a suitable stone flake and minimal polish to produce a blade.

AR6925 (Fig.150) is a typical flake adze, made of pale grey Tahanga basalt. Lateral reduction and a well ground bevel and blade do not disguise the flake origin, the curve of which is utilised in the final form. This adze was found near the Tipitai homestead. The length is 121 mm and blade width 29 mm.

Fig.153 illustrates an unusual flake adze (AR6953) which has resulted from damage done to a larger adze, possibly of Type 4A — 'hogback' — form. Polish and hammer-dressing display the origin of the flake. The stone is green Waiheke Group greywacke. Minimal polishing on the front and back has produced an effective, slightly curved blade. The length is 88 mm and width of the blade is 16 mm.

A well finished small flake adze is AR7172.9 (Fig.151). This is polished to some degree front and back and down the narrow sides. The minimal bevel creates an effective cutting edge. The measurements of this complete adze are only 39 mm length and 21 mm blade width. The maximum thickness is only 8 mm. It is made of Tahanga basalt. Fig.152 shows the blade end of a similar small adze (AR7172.18) made of black basalt. What survives is 28 mm in length with an 18 mm blade and maximum depth only 6 mm.

Other flake adzes are not illustrated. AR6936 is a crudely prepared argillite rough-out with virtually no polishing visible. Approximately one-quarter of the blade has been broken off. The overall dimensions are 91 x 33 mm. Also in argillite, this time of a green colour, is AR6919. Again this item is only flaked and partially formed. It measures 62 x 26 mm. AR6947, made of black basalt possibly from Tahanga, is 59 x 33



Figs. 146-153. 'Hogback' and flake adzes, Manukau South Head district. 146-149. 'Hogback' adzes. 146. AR6943. 147. AR6930. 148. AR6935. 149. AR6916. 150-153. Flake adzes. 150. AR6925. 151. AR7172.9. 152. AR7172.18. 153. AR6953.

mm in size and has been flaked only and never brought to completion. A well-finished flake adze in pale grey Tahanga basalt is AR6967. The 28 mm blade and steep, well-finished bevel show signs of use; the butt end is missing.

FISHING SINKERS

In the Brambley Collection is a total of 105 fishing sinkers. These include 26 in the 1938 deposit, now held in the Ethnology Department (23901.1-27; although included with sinkers, 23901.18 shows no sign of modification), and 79 in the Archaeology Department collection given by Mrs Brambley in 1981 (AR7030-7050, AR7053-7105, AR7329-7331, AR7402-7403). A further ten sinkers marked 'Wattle Bay', which were transferred to Auckland Museum with the university collection in July 1982 (AR7417: AU260-264, AU521-525), are not included in the following analysis.

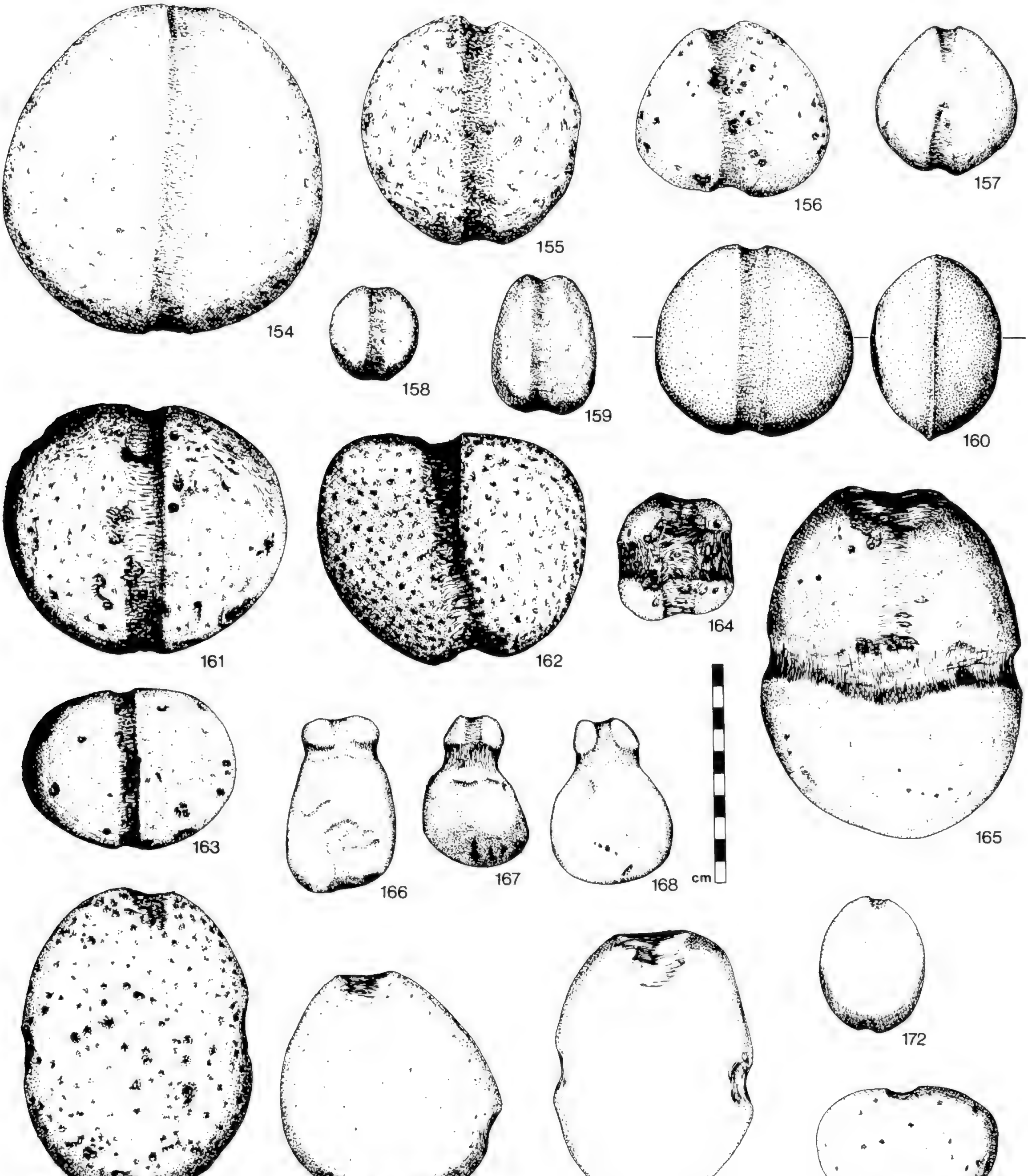
Almost all the sinkers are unprovenanced except to the general Awhitu-Manukau South Head shore. Three are specifically located to the Matatuahu site: AR7055 (Fig.169), AR7058 and AR7067 (Fig.166). An unusual item (AR7049) made of a water-rolled white quartz pebble pecked around its long axis Mrs Brambley states was found on the shore just west of the Tipitai homestead.

Most sinkers are made of andesite or basalt ranging from comparatively fine-grained to highly vesicular material. An important group of *ca.* five small sinkers including AR7030 (Fig.160), AR7060 (Fig.168) and AR7067 (Fig.166) are made of consolidated iron sand. Fewer still are made of greywacke and one each are made of quartz and sandstone cobbles. Water-rolled boulders and cobbles of the raw materials are to be found on the shores of the entrance to Manukau Harbour.

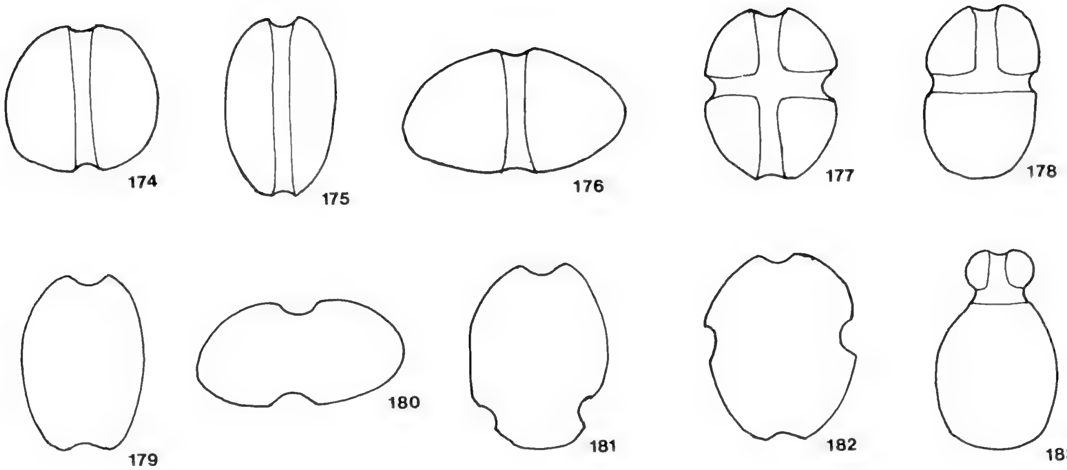
Sinkers come in a wide variety of sizes. The smallest is 68 g and measures no more than 40 mm in its maximum dimension (AR7090; Fig.158), the largest weighs 4.35 kg and measures 189 x 102 mm (AR7036). The preferred shape is a slightly elongate rounded (water-rolled) cobble or stone, usually of flat or relatively flat sides.

A range of sinkers is illustrated in Figs. 154-173. Notable is the beautifully made AR7030 (Fig.160), of consolidated iron sand with a carefully finished groove pecked out around the circumference. It was recovered from a stream bed at the beach a kilometre west of the Matatuahu site. Other sinkers range from comparatively well-prepared examples with a lashing groove around the selected stone to pebbles or stones which have been minimally notched or bruised at two opposite margins to allow the cord a secure hold.

A simple typology may be devised to allow some description of the Brambley Collection sinkers as a whole (Figs.174-183). Sinkers may be notched for tying — with two, three or four notches around the circumference of a comparatively flat water-rolled stone (Figs.179-182; and see Figs.169-173). At its simplest two notches may be at opposite sides of the short or long axis of a characteristically elongate pebble. A groove may extend all or almost all the way around the long or short axis of a stone (Figs.174-176; and see Figs.154-163). Occasionally such grooves may extend around a



Figs. 154-173. Fishing sinkers, Manukau South Head district. 154. AR7081. 155. AR7045. 156. AR7094. 157. AR7059. 158. AR7090. 159. AR7097. 160. AR7030. 161. AR7046. 162. AR7035. 163. AR7062. 164. AR7092. 165. AR7043. 166. AR7067. 167. AR7098. 168. AR7060. 169. AR7055. 170. AR7079. 171. AR7040. 172. AR7050. 173. AR7082.



Figs. 174-183. Brambley Collection fishing sinker forms.

stone both ways (Fig.177; and see Fig.164), or all around one way and part way the other (Fig.178; and see Fig.165). A very different arrangement relies for line attachment on a knob fashioned at one end of the sinker, often improved by a groove for added security (Fig.183; and see Figs.166-168).

Of 29 sinkers pecked or bruised at the margin only, 23 (80%) were designed to hang down the long axis. Similarly, of a total of 72 items which have grooves all or almost all the way around, 48 (67%) are grooved over the long axis and thus were designed again to hang down the long axis. Of the ten identified attachment arrangements as shown in Figs.174-183, 93 sinkers (89% of the total) belong to only four types (Figs.174-176,179).

HOANGA

It is not always clear with casual finds of smooth sandstone blocks or fragments whether the items have actually been used as grinding stones (*hoanga*), or if the smooth finish is natural. Among thirty or more items listed as '*hoanga*' or fragments thereof in the Brambley Collection many may be entirely natural; only half the total give any confidence that they were in fact once used. The raw material is coarse to fine sandstone with rare items of andesite (which, however, fall within the group of doubtful items). Examples are illustrated in Figs.184-194. the only items provenanced to the Matatuahu site (and already introduced above) are AR6989 (Fig.186) and AR6990 (Fig.185).

Perhaps the most distinctive *hoanga* in the collection is AR6996 (Fig.194), found below high tide in the bay Te Rua o Kaiwhare, east of the Matatuahu site. This item is 140 x 120 x 45 mm in size. Evidence of much use is to be seen in the two strongly dished sides of the stone, with grooves or striations across the surfaces. The material is a fine-grained sandstone. A larger *hoanga*, also still intact, is AR6991 (Fig.184). Made of

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Figs. 184-186. *Hoanga*, Manukau South Head district. 184. AR6991. 185. AR6990. 186. AR6989.

similar fine-grained sandstone to the previous item, this *hoanga* has two slightly dished surfaces (visible left and top in the illustration) which provide evidence of use. Mrs Brambley recalls that this grindstone may have been found at Tarataua or Te Rua o Kaiwhare.

Other illustrated *hoanga* are made mostly of fine-grained soft sandstone: AR6993 (Fig.188), AR6997 (Fig.189) and AR6998 (Fig.191) all display grooves and dished surfaces which result from polishing and sharpening activity. Other items of coarser sandstone are AR7002 (Fig.187) and AR7006 (Fig.192). Another comparatively coarse piece of grey stone has small round pebble inclusions (AR7003; Fig.190). A slightly concave polishing surface is visible on one side. This item is broken off the corner of a larger original *hoanga*. Very similar, but not shown is AR6992. The remaining illustrated piece is AR6986 (Fig.193) which has broken off a large piece and which may have had three sides used for polishing.

The range of *hoanga* in the Brambley Collection suggests grinding and polishing of stone surfaces for adzes, chisels and patu, the sharpening of adze and chisel blades, and the shaping of bone and stone artefacts. Smaller items would have been hand-held for working.

Although apparently collected as *hoanga*, material not illustrated seldom displays evidence of actually having been used as such: suitable raw material and the presence of flat surfaces are on their own insufficient evidence (AR6984-85, AR6987-88, AR6990, AR6992, AR6994-5, AR6999, AR7001 and AR7004-5). A further fifteen small fragments of *hoanga*, including *ca.* ten with parts of polishing or grinding facets, are catalogued with files under AR7173.

PATU

A highly polished blade fragment of a patu (AR7172.1) is made of a relatively coarse-grained green Waiheke Group greywacke. The width is 85 m and maximum thickness is 20.5 mm.

MISCELLANEOUS STONE MATERIAL

Nephrite

In addition to the fragmentary nephrite material recovered from the Matatuahu site there are other nephrite pieces in the Brambley Collection. A triangular piece 3 mm thick and *ca.* 25 mm in length on each of the three sides has been broken from an adze blade and since polished on the broken face to form a tiny but serviceable blade (AR7176). Mrs Brambley states that this item was found on the east side of Tarataua. AR7175 is a 19 mm long section of chisel (or pendant?), 14 mm wide and 6 mm deep, of rounded rectangular cross-section rendered in dark green nephrite. AR6917 is the greater part of a small gouge, missing only some blade and an unknown but limited amount from the butt. What remains is 45 mm long; the almost circular cross-section is 11 mm in diameter. The stone is deep green/black nephrite.

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Figs. 187-194. *Hoanga*, Manukau South Head district. 187. AR7002. 188, AR6993. 189. AR6997. 190. AR7003. 191. AR6998. 192. AR7006. 193. AR6986. 194. AR6996.

Serpentine

An important item is a fragment of dark green serpentine, much of it highly polished (AR7177). The piece is 42 x 20 x 9 mm in size with polished surfaces suggesting an originally sub-triangular cross-section 20 mm across the base. The item from which this fragment has been broken may thus have been a large minnow-lure shank, or possibly an ornament — certainly it would have been too soft for use as an adze or chisel.

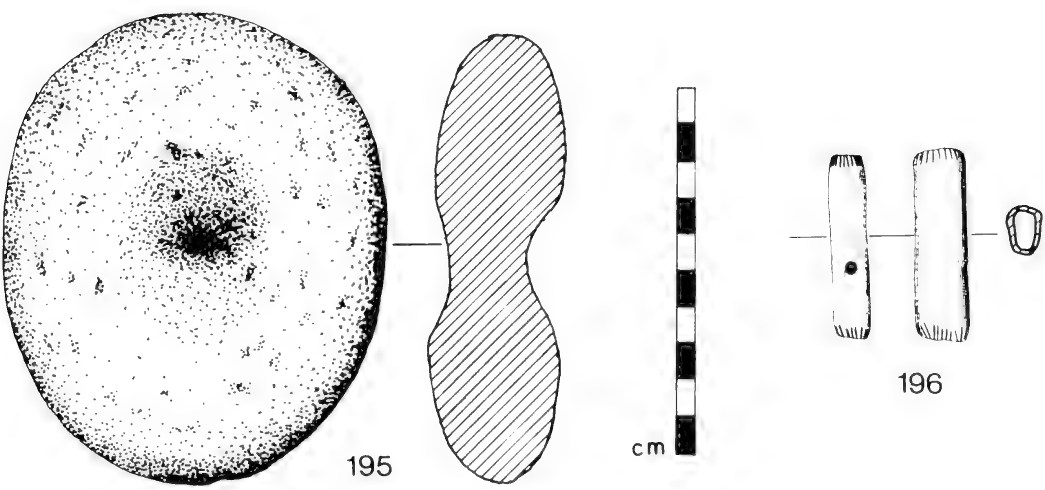
Serpentine from the Nelson region, is the common raw material for stone pendants of archaic form. The only other item made of serpentine in the Brambley Collection is the twin-lobed pendant (AR7000, Fig.29) provenanced to the Matatuahu site — which may well have been the source of AR7177 as well.

Item of unknown use.

Fig. 195 depicts a flat water-rolled stone with shallow holes formed each side by hammering the coarse gritty basalt (AR7009). On one side there are traces of *kokowai*. In places on the narrow edge are signs of use as a hammerstone — which may also account for the holes on the sides. Alternatively this unusual item may itself be an object in the course of manufacture. Mrs Brambley states that this artefact was found at Te Rua o Kaiwhare.

TOGGLE

A well-made bone toggle was found on the beach below the house at Tipitai (AR7259; Fig.196). It is 52 mm long with a flat oval cross-section, 14 x 11 mm, and is



Figs. 195,196. Miscellaneous items, Manukau South Head district. 195. Artefact of unknown use. AR7009. 196. Toggle. AR7259.

made of a section of albatross or mollymawk wingbone. Notches provide decoration around both ends. This item probably relates to the nineteenth century Tipitai kainga.

EUROPEAN MATERIAL

Without exception material of European manufacture came into the Auckland Museum in 1981 with the main part of the Brambley Collection. It includes bullets, gunflints, coloured beads, clay pipe fragments, a cut nail and the head of a small hatchet. Mrs Brambley has recalled that the gunflints, beads, and clay pipe pieces came from the foreshore below the Tipitai homestead, the hatchet head from the cowyard at Tipitai and the bullets from Tarataua.

Clay pipes

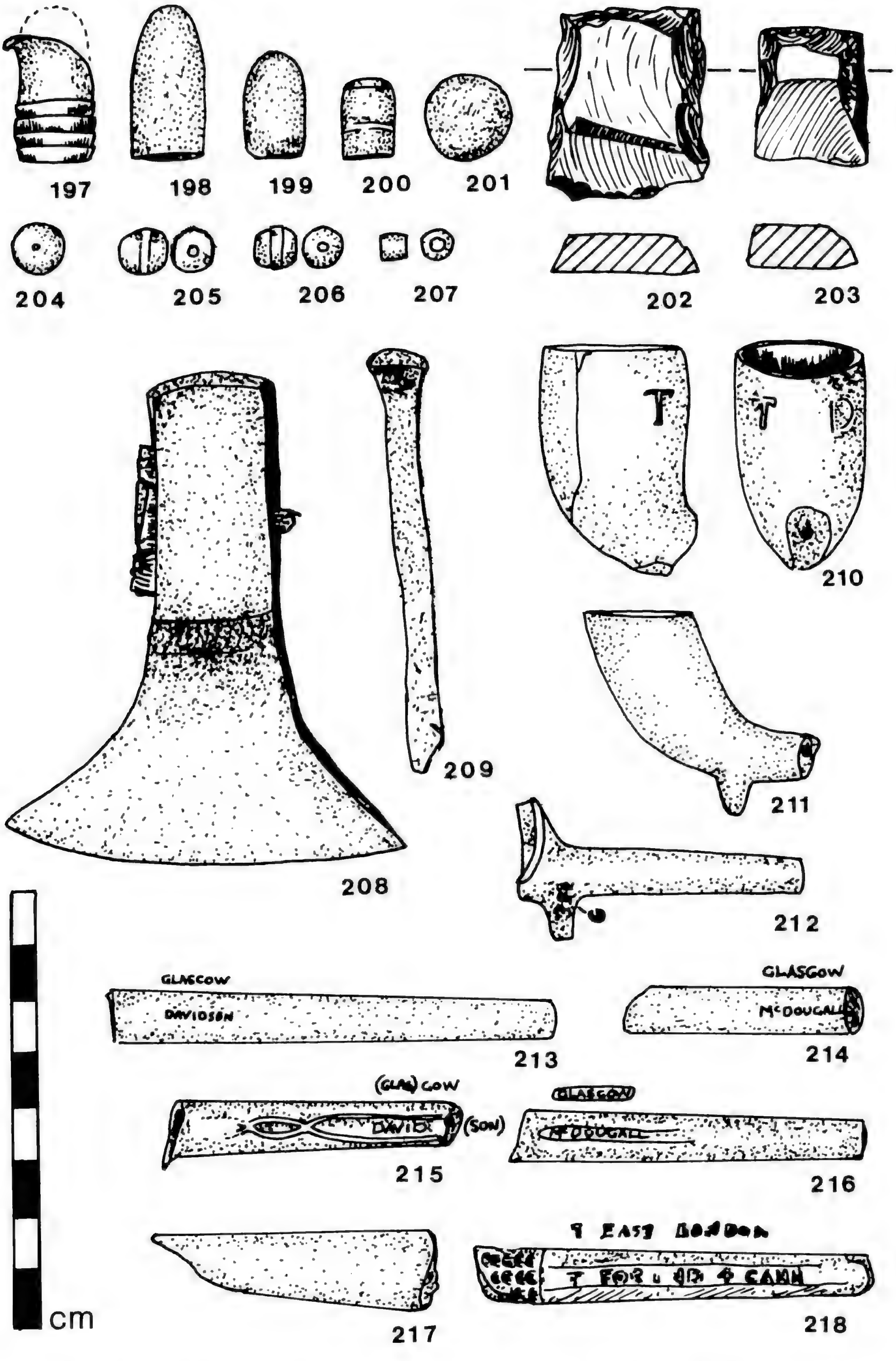
Two clay pipe bowls and 18 stem sherds (AR7210-7229) weigh a total of 117 g. The bowls include an embossed 'TD' (AR7222, Fig.210) possibly made by Thomas Davidson and Company of Glasgow, and a smaller unmarked bowl with spur (AR7210, Fig.211). One stem sherd includes an embossed spur (AR7225, Fig.212). There is also an unmarked stem sherd with a splash of glaze at the grip end (AR7214), and a piece of exceptionally heavy stem (AR7221, Fig.217).

Among stem sherds are represented two Glasgow manufacturers, Davidson and McDougall, and T. Ford of London. Two Davidson stems (AR7218 and AR7224) are of different designs (Figs. 213,215). Three McDougall stems again have two different marks (AR7215, Fig.214, and AR7219; and AR7213, Fig.216). Duncan McDougall began making pipes in 1846, the firm continuing in production until 1967. Thomas Davidson's Caledonian pipeworks was in business from 1863 to 1910 (Oswald 1975:205).

The London maker, Ford, is apparently unrepresented in other New Zealand archaeological collections. A highly decorated stem is embossed 'T. FORD. No. 4(1.?) CANN(ON ST)/(T?) EAST LONDON' (AR7212, Fig.218). Atkinson & Oswald (1969) list T.F. Ford as operating from Cannon Street in the years 1836-53.

Ammunition

Ten lead bullets (AR7200-7209) include a range of ammunition of the middle years of the nineteenth century. There are two pistol bullets, both of them *ca.* 10 mm in diameter. One weighs 10.8 g and has a hollow nose and two cannelures (AR7209), while the other weighs 13.3 g (AR7203, Fig.200). Two balls are both 16.5 mm in diameter: one, 26.0 g (AR7200, Fig.201), the other, 22.9 g (AR7201). One .577 Enfield (1853 Pattern) bullet has clearly been fired (AR7204). Two Type 5 Snider bullets (with three cannelures) date from the late 1860s introduction of the Snider breech loading conversion of the Enfield (AR7208, Fig.197, and AR7206). Two conical bullets of *ca.* 13.5 mm diameter, weigh 24.2 g (AR7207, Fig.199) and 32.5 g (AR7202, Fig.198) respectively. A single bullet of *ca.* 11.2 mm diameter and 28.9 g is mushroomed through impact (AR7205).



Figs. 197-218. Items of European manufacture, Manukau South Head district. 197-201. Ammunition. 197. AR7208. 198. AR7202. 199. AR7207. 200. AR7203. 201. AR7200. 202,203. Gunflints. 202. AR7190. 203. AR7192. 204-207. Trade beads. AR7198. 208. Axe head. AR7197. 209. Spike nail. AR7199. 210-218. Clay pipe material. 210. AR7222. 211. AR7210. 212. AR7225. 213. AR7218. 214. AR7215. 215. AR7224. 216. AR7213. 217. AR7221. 218. AR7212.

Gunflints

Eight gunflints (AR7189-7196) were probably made at Brandon, Suffolk, in England; illustrated are AR7190, Fig.202, and AR7192, Fig.203). In the first half of the nineteenth century the old flint-lock musket was gradually replaced by a percussion-lock weapon with percussion cap enclosing the igniting powder. The last sale of gunflints to the British army was made in 1838. In New Zealand, flint-lock weapons from which the gunflints found on the Tipitai foreshore could have come were still in use in the second half of the nineteenth century.

Trade beads

Thirteen trade beads include seven different types (AR7198). Five brown beads have a raised belt around the centre (Fig.206). Two red examples might have come from the same mould. Two slightly larger pale blue opaque beads have the same basic shape (Fig.205). A larger translucent glass bead has a tiny perforation (Fig.204). A deep blue cylindrical bead is the only one in the collection not of the spherical shape (Fig.207). Two orange beads include a plain example of dull finish the same size as the common brown type and one smaller example of shiny finish with the raised belt around the centre.

Iron

A hatchet head (AR7197, Fig.208) and three-inch (75 mm) cut nail (AR7199, Fig.209) complete the European material.

Discussion

THE GEOGRAPHICAL SETTING

Manukau Harbour (see Fig.1) is the second largest of a series of eight drowned river valley harbours strung along the northern half of the west coast of the North Island of New Zealand. Its area is 340 km^2, of which 145 km^2 is exposed mudflat at low tide (Auckland Harbour Board 1978 II:91). The harbour opens to the sea by way of a 2 km wide, 30 m deep channel which cuts between two blocks of high country lying along the west coast (Figs.219,220). Shifting sand bars and shoals extend 5 km offshore from the harbour mouth.

North-east of the harbour the Tamaki Isthmus is the narrowest part of the North Island. On the other side of the isthmus is the Waitemata Harbour which opens to the sheltered waters of Hauraki Gulf. Manukau Harbour thus makes up part of the easiest route between the east and west coasts. Until land transport was developed in the present century, this east-west route with canoe portage was of the utmost importance in travel, transport and communication.

Fig. 219. Manukau Harbour entrance looking east with the harbour beyond. The South Head cliffs can be seen upper right with the collection area to the left. In the foreground is the Whatipu sand flat which has been built up since the mid-nineteenth century.
Photo: Whites Aviation

Inland of Manukau Harbour are fertile lowlands of volcanically derived soils. To the south-west these include the rich loams of the Pukekohe district and surrounding region. Younger volcanic soils to the north, including the Tamaki Isthmus, were highly suited to Polynesian cultivation techniques. Throughout the northern part of these lowlands are volcanic cones, explosion craters and lava fields which today provide the most characteristic features of the natural landscape of the Auckland urban area.

Between Manukau Harbour and the open west coast is the 150-300 m high sandstone ridge of the Awhitu Peninsula. Sheltered gullies along the harbour side of the peninsula provide limited areas of fertile soils for gardening and excellent locations for settlement. North of the harbour entrance is the rugged Waitakere Range which rises to almost 500 m above sea level.

Manukau Harbour itself is a rich biological resource, and was undoubtedly richer in the past before environmental pollution and over-exploitation of the European period. The most numerous fish taken commercially today are flounder (*Rhombosolea plebeia* and *R. leporina*) and grey mullet (*Mugil cephalus*). Also taken

Fig. 220. Manukau Harbour entrance looking west. Left foreground is Te Rua o Kaiwhare and Te Pirau Point, with the beach in front of the Matatuahu site just visible immediately beyond.
Photo: Whites Aviation

are sharks (mostly dogfish) and rays, trevally (*Caranx lutescens*), snapper (*Chrysophrys auratus*), kahawai (*Arripis trutta*), parore (*Girella tricuspidata*), yellow-eyed mullet (*Aldrichetta forsteri*) and tarakihi (*Cheilodactylus macropterus*) (Auckland Harbour Board 1978 II:63). While this is unlikely to match pre-European productivity, it does indicate the variety of species which may have been available in the past. Shellfish commonly taken today are pipi (*Paphies australe*), pupu (*Amphibola crenata*) and cockles (*Chione stutchburyi*) from soft shores, scallops (*Pecten novaezelandiae*) from the extensive sand banks of the central harbour, and green mussels (*Perna canaliculus*) and kina (*Evechinus chloroticus*) from the rocky shores of the harbour entrance.

Most land surrounding Manukau Harbour is now being farmed. The Awhitu Peninsula is under grass for livestock farming, with small patches of native bush surviving in places and extensive dune areas in parts exposed to the west. The rich soils of the Manukau lowlands are used for dairy farming and, increasingly, horticulture. Clark (1983:252) describes briefly the early nineteenth century vegetation of the districts south-west of the harbour, where fern and manuka along the shore was backed by dense forest dominated by kahikatea and tawa. The urban area of greater

Auckand now covers Tamaki Isthmus and much of the north-west side of the harbour, as well as extending into the bush of the Waitakere Range. The isthmus itself was under fern and scrub in the early nineteenth century, while the rich natural and historic landscape focussed on the volcanic cones has since suffered enormous damage through quarrying and urban growth. After extensive kauri milling of the nineteenth century the steep faces of the Waitakere Range which lie above the entrance to Manukau Harbour are now rapidly regenerating into kauri and other forest.

The immediate setting of the farm and foreshore where the Brambley Collection was made is dominated by the narrow outlet of the harbour and the high hills behind (Figs.219,220). At Wattle Bay itself there is an extensive beach and tidal area backed by flat ground which extends to the south and west up steep-sided gullies. Westwards the country is so steep that road access to Tipitai uses the beach, and then only at low tide. Above the shore the hills rise steeply — precipitously in places — to the Manukau Heads trig station at 285 m above sea level. Several small gullies rise sharply to the west and south-west.

Along the shore are the prominent points of Tarataua (Cake Island) and Te Pirau Point (see Figs.2,220). Sandy beaches connect these points and allow the latter to be rounded on foot at low tide. Tarataua Point is connected to the mainland by a narrow isthmus. East of Tarataua is a broad inter-tidal flat exposed at low tide; west is a shelving sandy beach.

To the extent that it is known, late ('Classic Maori') material and objects of European manufacture come mostly from the western part of Wattle Bay. Some items were found on the broad inter-tidal flat in front of Tipitai homestead itself. The narrow homestead gully mouth was occupied in the early 1840s by a small Maori settlement from which the Brambley farm took its name (Fig.221). At the mouth of the much larger gully where the road now ends was the nineteenth century Maori settlement of Awhitu. A large part of the material from the Wattle Bay beach doubtless originates from the nineteenth century and earlier settlements at Tipitai and Awhitu (see Fig.2).

MATATUAHU: THE LOCATION

The Matatuahu site is located at the base of a 20-40 m high sand dune which rises up the steep hill face west of Te Pirau Point (Figs.222,223; see also Fig.2). Clearly there was once a sand flat here which extended some distance off the present shore. Mrs Brambley recalls a small part of this area surviving as low dunes when she first visited the place. Coulthard (1963:opp. p.144) depicts a bare sand flat at the foot of the high dune in 1906, apparently much more extensive than that which exists today. Almost all the material collected from the site has been found on the beach, mostly after spring tides and stormy weather has resulted in active erosion at the base of the dune.

A traditional story of the adjacent bay Te Rua o Kaiwhare tells of the destruction of all flat land in the bay back to the steep hillside and cliffs in a single great storm. The calamity was put down to a taniwha named Kaiwhare or "eater of houses" (Coulthard 1963:145-146). The vanished land was probably only part of an extensive sand flat

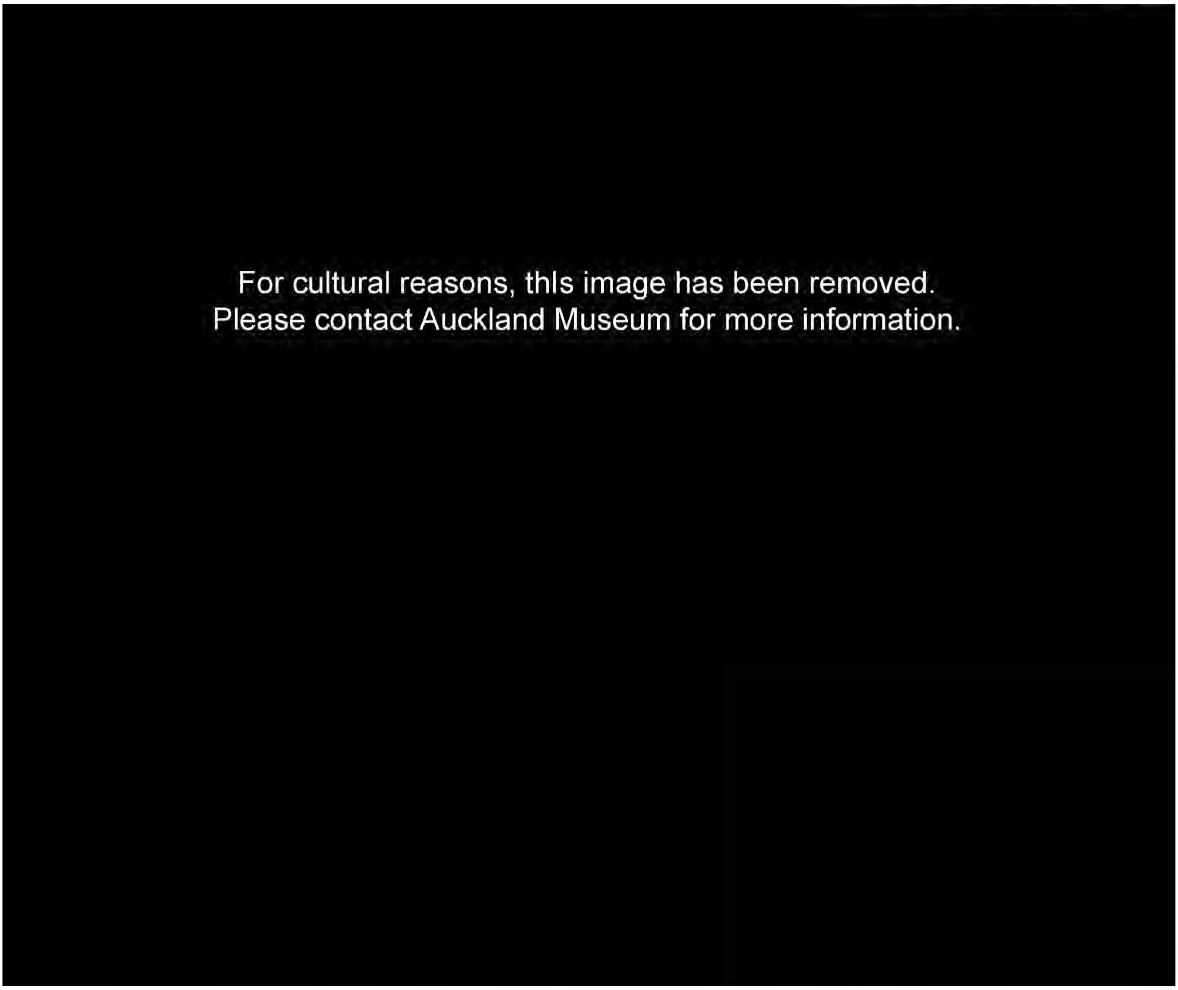


Fig. 221. "Native Settlement Tipitai Manukao Hr New Zealand Xmas 1843", Edward Ashworth.
Alexander Turnbull Library

along the southern shore of the Manukau Harbour entrance. Destruction of the Matatuahu site may not have occurred overnight but it has been no less complete.

Seaward of Manukau South Head there once existed an even more extensive sand flat. The vanished land of Paorae is said to have stood nearly 6 km out to sea and extended south to the mouth of the Waikato River (Diamond & Hayward 1979:28-29). The destruction of Paorae by the sea was completed only this century; as recently as the First World War cattle were run on a 100 acre 'island' which stood off the cliffs below South Head. Since the mid-nineteenth century an equivalent sand flat has formed off Whatipu at the north side of the harbour entrance (Fig.219).

Paorae and the lost land along the southern shore of the harbour entrance help make sense of the location of the Matatuahu site, now isolated between steep hills and

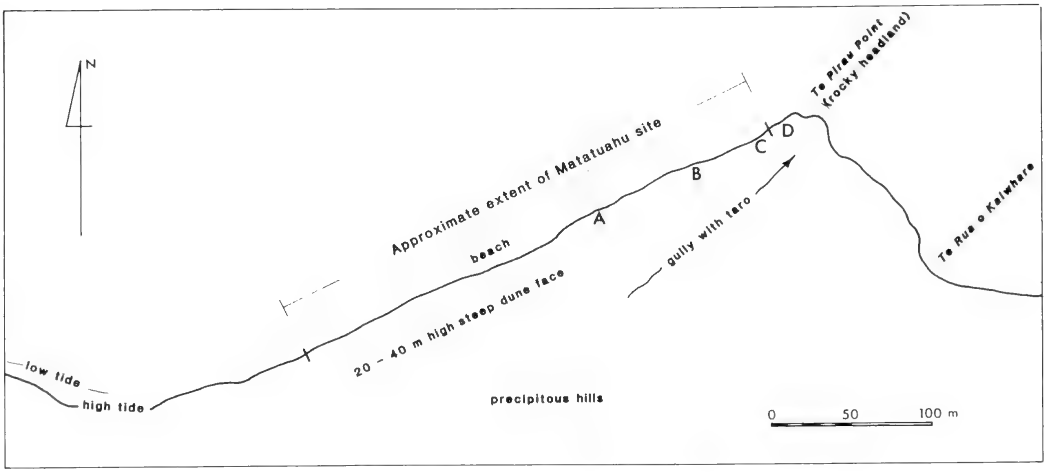


Fig. 222. Sketch map of Matatuahu site. A. Approximate location of University excavation, November 1960. B. Approximate location of Brambley excavations. C. Twin-lobed pendant find spot. D. Waterfall (fresh water).

Fig. 223. Matatuahu site at foot of dune face. Te Pirau Point can be seen at the far (east) end of site with Puponga Point on the north side of Manukau Harbour in the distance.

the sea. There may once have been a large flat area adjacent to the site of light sandy soil ideally suited to kumara and other cultivation. Indeed, there may have been more settlements like 'Matatuahu' on the extensive lands here which are now lost to storms, tides and changing currents.

At Matatuahu fresh water has probably always been obtainable from a waterfall which comes off the low cliff at Te Pirau Point. The gully behind the dune face is now filled with wild taro (*Colocasia esculenta*).

When Percy Smith surveyed the Awhitu/Tipitai district in February 1864, he marked the "Te Rua o Kaiwhare Burial Ground" extending from a point ('Kutete') half-way along the beach backed by the Matatuahu site to Te Rua o Kaiwhare itself (Smith 1865). This burial ground is marked in subsequent cadastral and other maps of the district.

Mrs Brambley states that there was a Maori burial ground at Te Rua o Kaiwhare where there were also some burials of victims of the February 1863 wreck of H.M.S. *Orpheus*, and that these were all washed away in the course of one of the episodes of destruction of the sand flat there. Coulthard (1963:opp. p.144) depicts a human skull on the sand flat ('Kuru-Tete') before the Matatuahu site. It cannot now be certain whether this is from a Maori burial or if it is one of many unrecovered victims of the *Orpheus* disaster.

The only human bones which Mrs Brambley recalls being associated with the Matatuahu site are a skull and some post-cranial material which eroded from the dune near the east end of the site to be brought to the Brambleys' attention by a passing fisherman. There is no human bone in the Brambley Collection.

MATATUAHU: THE ARCHAEOLOGY

The Matatuahu site extends from where the sand dune face ends a few metres short of Te Pirau Point, approximately 320 m westwards towards South Head. In the past, two New Zealand Archaeological Association site record numbers have been assigned to the site: N46-47/17 for the Brambley excavation area and N46-47/16 for the University of Auckland Archaeological Society excavation (see Fig.222). There is, however, no reason to suppose that more than one site is involved. From her experience of the site Mrs Brambley describes an occupation layer which dips westwards so that it is scarcely above the high tide mark at the west of the beach. Fig.222 shows the approximate location of the Brambley and university excavations.

The first published reference to the Matatuahu site is included in Jolly's 1960 note, "Evidence of Archaic occupation along Auckland west coast." In it Jolly draws attention to archaic material, notably adzes, moa bone and a harpoon point, from the area between the Waikato and Manukau Heads. Although he does not give the actual site or its location it is Matatuahu which is being referred to. Jolly goes on to suggest that other such early sites may be found in the Raglan and Kawhia districts.

The November 1960 university excavation took place over one weekend. The steeply rising dune face above the remains of the site greatly reduced the amount of work which could be carried out. An area of 30 x 8 feet (9.14 x 2.44 m) was excavated (Ambrose 1961:86). Figs.224 and 225 illustrate the excavation and its location. In addition to the results described by Ambrose, Janet Davidson has recalled to the author that a large amount of fishbone was found in the excavated area, none of which was kept, and that some moa bone was also found.

In his report Ambrose (1961:85-86) describes three separate groups of material. Fragments of charcoal and obsidian and a ". . . small vesicular stone abraded in honing" were found in dune overburden above the actual cultural layers, apparently having been redeposited from higher up the dune face.

Two *in situ* cultural layers were found. The upper layer is described as (Ambrose 1961:86) as follows:

> "The interface between the dune and the underlying deposits defined an undulating, slightly off-level surface representing the last preserved evidence of human occupation at the site. The only evidence of any structural remains was in the form of two shallow post holes. The excavated area, gridded for recording, measuring 30ft. [9.14 m] along the beach front and 8ft. [2.44 m] back, displayed a sparse scattering of cultural evidence at this topmost level. The varied material included the badly preserved bones of an individual animal, possibly dog. In a confined 18″ [460 mm] square sixty crop stones were found, while in other parts many chert and obsidian flakes, drill points, an adze roughout, a fishhook blank and a nicely polished chisel were recovered."

Below this upper occupation layer was a discontinuous layer of relatively sterile sand probably representing incipient dune formation. Below the sand was another layer.

> "The lowermost layer was typified by rich carbonaceous deposits and rested with a sharp division on a sterile natural substratum at a horizon only a couple of feet above high spring tide level. A fragment of polished adze, part of a sandstone file, several stone flakes and a drill point were all that was recovered from this layer."

The prospect of there having been two distinct occupation levels in the Matatuahu site is difficult to resolve. It is probably safest to regard the site as being of one occupation period, whether or not there is more than one cultural layer at any part of it. Certainly, the material recovered from the site which takes up a large part of this report can only be treated as a single assemblage. An example of the Matatuahu occupation layer, probably near the east end of the site, can be seen in Fig. 226. A 10-25 cm deep deposit of shell and charcoal is overlaid by a thin black layer.

During a March 1982 visit to the site by the author in company with Messrs R.G.W. Jolly and Jim Brambley (son of the donor) the toe of the dune was cut back at a point *ca.* 45 m from the east end of the site to locate the occupation layer. Here the cultural layer proved to be *ca.* 1.7 m above the rear of the beach and consisted mostly of shell as much as 10 cm deep. This was composed principally of highly compacted

Figs. 224-225. November 1960 University of Auckland Archaeological Society excavations at Matatuahu site. 224. View west towards Manukau Heads. 225. View east showing dune face and overburden.

fragmentary mussel (*Perna canaliculus*) and some cockle shell, with rare paua, *Turbo smaragdus* and pipi. Fishbone, charcoal and oven stones were also present. Where the shell ended a thin black layer continued the occupation surface.

MATATUAHU: THE HISTORICAL AND REGIONAL CONTEXT

The Matatuahu material in the Brambley Collection comprises what is without doubt the most notable archaic assemblage of the Auckland region. In terms of the quantity and variety of early stone tools in particular, the assemblage is only surpassed by the great rivermouth settlement sites of the South Island. Indeed, the archaic material in the collection as a whole compares much more closely with that of South Island sites and collections than it does with North Island sites, especially those north of the Cook Strait region.

Three years after the university excavation Green (1963:52-53) included the Matatuahu site in the 'Development Phase' (*ca.* 1100-1350) of his Auckland Province cultural sequence. Davidson (1982:35) suggests that the site may date from earlier than 1300 A.D. This conclusion regarding the date of occupation is based upon the artefact

Fig. 226. Matatuahu site showing shell lense beneath black living surface. Photograph probably taken in 1960.

Photo: R.G.W. Jolly

assemblage. Seven finely finished chisels of early form, three side-hafted adzes, rectangular and lenticular cross-sectioned, and 'hogback' and 'Samoan' type adzes are all located to the Matatuahu site and all are strongly archaic in style. Other adzes and chisels, while not securely located, may also come from the site, or from the nearby foreshore, and probably relate to the Matatuahu occupation. Other characteristically archaic items include the twin-lobed pendant, harpoon, and one-piece fishhooks in moa and sea-mammal bone. The files, drillpoints and hammerstones are also more typically, though not exclusively, found in archaic contexts than in later sites.

Dating evidence for the Matatuahu site provided by the presence of moa bone needs to be treated with caution. As has been argued above, moa bone seems likely to have been sub-fossil material brought to the site for industrial purposes and not the result of hunting moa for food.

Some of the wide range of stone material is itself suggestive of an early date of occupation. Metasomatised argillite from the Nelson district (see Fig.227) was the pre-eminent raw material for adzes and chisels in the early period; it is strongly represented in the Matatuahu assemblage, especially among chisels where four of seven items are made of black stone from Mt Ears, D'Urville Island, and a fifth is of material from the other easily identifiable D'Urville Island source at Ohana. A second Nelson stone to be represented is serpentine, the use of which is almost entirely confined to pendants of archaic style such as the Matatuahu twin-lobed pendant (Fig.29).

Basalt from Tahanga near Opito Bay on the east coast of the Coromandel Peninsula is also commonly associated with tools of early styles. In the Matatuahu assemblage it is represented by a chisel and side-hafted adze, five rectangular cross-sectioned adzes and *ca.* 18 other less distinctive items and fragments. In addition there are two important triangular cross-sectioned adzes in the collection which are not located to the N46-47/17 site. the 'hogback' chisel from the foreshore at Tipitai may originate from a locally important basalt source near Raglan and is significant as the most northerly example of this little known raw material thus far identified.

The third important raw material for adzes and chisels in the Matatuahu assemblage is Waiheke Group greywacke (Schofield 1967). Among items from the site are a finely-flaked chisel, two side-hafted adzes, a lenticular cross-sectioned adze and a fragment of a large 'hogback' adze. In the remainder of the collection is a second 'hogback' adze, a fragment of a rectangular cross-sectioned adze of early form and as many as 13 Duff Type 2B adzes.

Waiheke Group greywacke provided stone craftsmen of the Auckland/Hauraki Gulf region with a high quality raw material for tool making. The flaking quality of the stone appears superior to that of the better known Tahanga basalt, also a regionally important raw material for adzes of early forms. Waiheke Group greywackes are found from Rakino Island (north of Motutapu), southwards on other islands of the inner Hauraki Gulf and on the mainland along the eastern side of the Firth of Thames. While most material used for adze-making is green in colour, grey stone is not unknown. The quality ranges from a very even fine-grained material to coarser stone

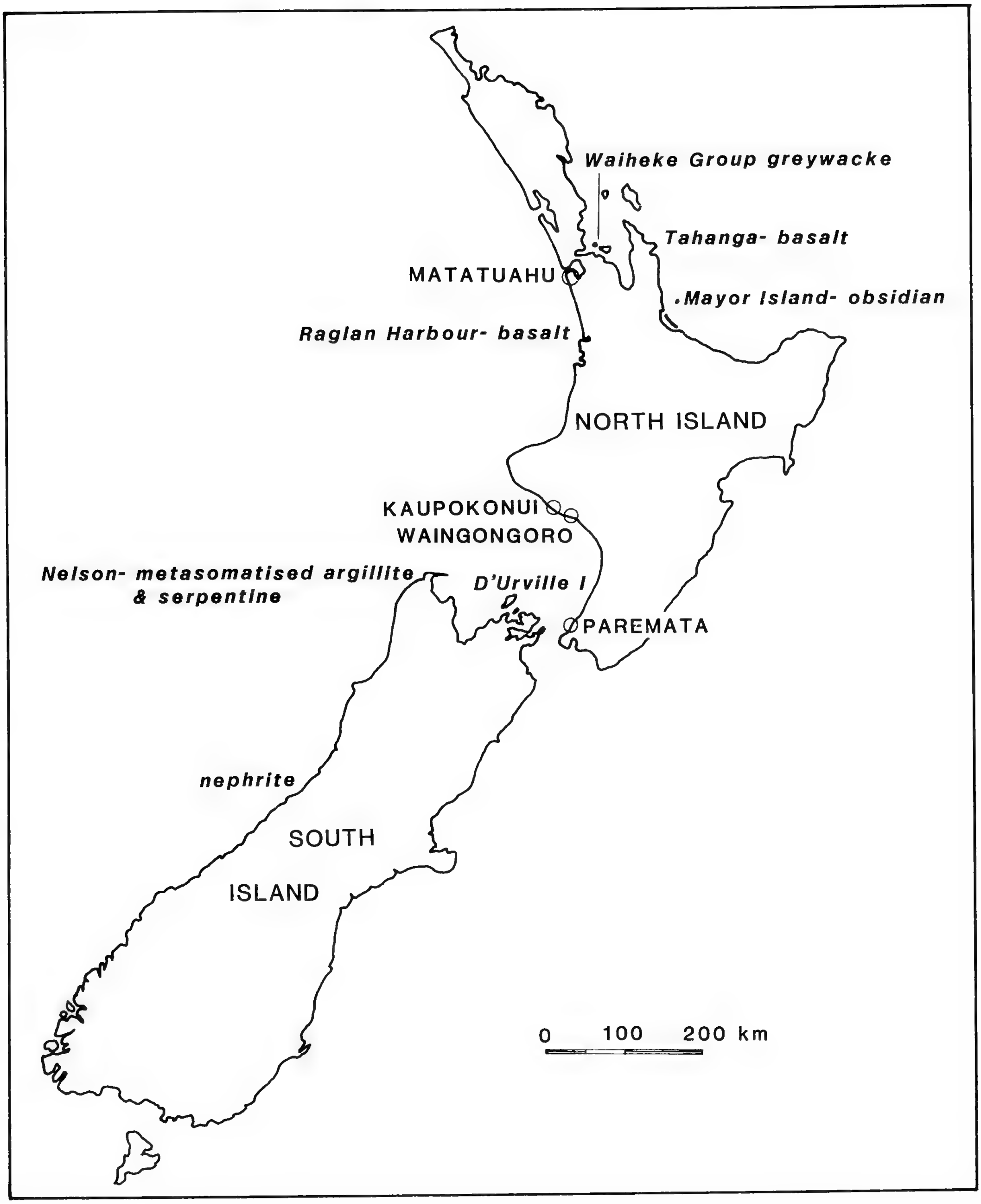


Fig. 227. Map of New Zealand showing sources of stone material in the Matatuahu assemblage and location of other major archaic sites on North Island west coast.

which is less amenable to accurate flaking. The material was worked not just at source locations, but at other settlement sites in the region as well — N46-47/17 provides an example. While Waiheke Group greywacke, Tahanga basalt and Nelson argillites have similar importance in the group of early adzes and chisels located to the Matatuahu site, it is notable that Waiheke Group greywacke is pre-eminent among later forms of unlocalised material (see Table 4).

Among obsidian from the Matatuahu site 81% is green in transmitted light and almost certainly from the Mayor Island, Bay of Plenty, source (Fig.227). Other grey material may come from a variety of source areas including Coromandel and Great Barrier Island, Taupo and Northland. Fragments of nephrite have come from the South Island, possibly the Taramakau/Arahura River district on the West Coast (Fig.227).

Matatuahu is an example of an important site type about which much remains to be learnt. It is a commonly held wisdom that most early sites are on the east coast of New Zealand. Only rarely are sites reported from the west coast which relate in their artefact assemblage or by C14 dating to the early phase of Polynesian settlement of New Zealand. It could be argued, however, that the west coast may have been just as important in the exploration and early settlement period but that for a number of reasons this is yet to be fully recognised. The loss of early sites may be greater on the west coast than on the east: on the North Island west coast prevailing westerlies have eroded the soft, young rocks of much of the coastline and elsewhere have built active dune systems, thus destroying some, possibly many, early sites. In addition there is an apparent willingness of archaeologists to add a few hundred years to most early dates obtained from east coast sites to arrive at a general settlement date for that coast of *ca.* 1000 B.P., (*ca.* tenth century A.D.). This results at least partly from a feeling that with a large number of sites now radiocarbon dated to 6-800 years B.P. there must be earlier occupation for this extent of settlement to have become established. The very few early sites on the west coast do not lend themselves to this kind of argument.

Among other notable west coast sites are the south Taranaki moa-hunting settlements at Kaupokonui and Waingongoro River mouths (Fig.227). These are very different in character from Matatuahu since they are most notable for their abundance of extinct bird bone. On present evidence the Taranaki sites, which almost certainly mark the first entry of man into the region, date from the thirteenth or fourteenth century (Prickett 1983:299). Another early west coast site is Paremata from which several moa species and other extinct birds have been identified (Davidson 1978:215-216). A fifteenth century radiocarbon date from the site is rejected by Davidson (1978:214); the date of first occupation may not differ greatly from that of the south Taranaki sites. Notwithstanding losses there are undoubtedly many other early settlement sites along the west coast of the North Island. At Raglan North Head, for example, artefacts collected from rapidly eroding sites in mobile dunes are strongly suggestive of early occupation. The Waikato coast and, indeed much of the remainder of the North Island west coast, will almost certainly repay a close search for early sites. Existing museum material may serve to give the search some direction.

Acknowledgements. My foremost acknowledgement is to Mrs Mavis Brambley and the late Mr Bill Brambley for their generous gift to the Auckland Institute and Museum on which this account is based. Mrs Brambley has spent much time at home and in the museum recalling the circumstances of discovery and the provenance of many individual items and has been helpful and interested throughout the production of this report.

Archaeologists who have had an interest in the collection before it came into the museum include Jack Golson, Wal Ambrose, David Simmons, Bob Jolly and Garry Law. In addition to their early attempt to catalogue some items in the collection, Golson and Ambrose were responsible for the University of Auckland Archaeological Society excavation at the Matatuahu site in November 1960. Simmons very sensibly noted provenances directly on many of the items. Jolly and Law prepared the admirable 1977-78 catalogue of the collection.

Bob Jolly was also responsible for the first drawing the attention of the archaeological community to the Brambley Collection and the 'Manakau South Head' site. In recent years he has kept before me my commitment to writing up the collection for the museum *Records* and has contributed photographs of the site. Other archaeologists who have helped are Anne Leahy who has shared her photographs of the Matatuahu site and Janet Davidson who recalled what she could of the university excavation.

There have been two major contributions to the analysis of the collection and its preparation for publication. Brett Peacock catalogued the material into the Archaeology Department collection and is responsible for almost all of the excellent artefact drawings. Kath Prickett identified all the stone material, often to greater detail than I have been able to do justice in this account.

Other assistance with analysis was provided by Phil Millener (moa bone), Michael Taylor (dog and sea mammal bone), Reg Nichol (fish bone) and Wynne Spring-Rice (ammunition). Simon Best helped by alerting me to the wide range of Tahanga basalt in hand specimen appearance. Dante Bonica has been invaluable in many discussions on the sources and properties of various stone materials and the practicalities of working in stone and bone.

Thanks are also due to Brian Muir who made available his manuscript "Key to Archaeological Sites in the Waiuku region". Joan Lawrence prepared additional artefact drawings. Caroline Phillips is responsible for maps and plans (Figs 1,2,222 and 227). The Alexander Turnbull Library provided the Ashworth sketch. Mary Best typed the manuscript, much of it twice.

Writing up the Brambley Collection is a project that took much longer than expected because of the intervention of some years of more pressing museum commitments. I hope I will be forgiven therefore by anyone whose contribution to knowledge of the Matatuahu site or the collection has been overlooked here because it all happened so long ago.

APPENDIX 1

Brambley Collection material from outside the Manukau South Head area.

1. AR6911. Belfast, Christchurch. A Duff Type 1B 'spade-shouldered' adze. Made of volcanic material possibly from Banks Peninsula. Extensive haft polish on back, 204 x 62 mm. It is presumably this item, incorrectly attributed to 'Manukau South Head', which Davidson (1984:96) gives as a rare example of the spade-shouldered adze occurring in the North Island.

2. AR6945. Tahanga quarry, Coromandel Peninsula (from R.G.W. Jolly). Basalt rough-out of high triangular cross-section. 180 x 75 mm.

3. AR6946. "Limestone downs" south of Waikato Heads (M. Brambley, pers.comm.). Some flakes have apparently been struck off a ventifact preparatory to its being made into an adze. The material is greywacke-sandstone. 175 x 83 mm.

4. AR7234. Rangatira Point, Taupo. Circular pumice rubbing/polishing stone. *Ca.* 50 mm diameter, 29 mm deep.

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A MAORI BIRDMAN KITE
IN THE AUCKLAND MUSEUM

A description and an account of the conservation treatment

GERRY BARTON

AUCKLAND INSTITUTE AND MUSEUM

Abstract. This paper discusses conservation treatment needed to stabilise the fragile condition of a rare Maori kite in the Auckland Museum collection. Identifications were carried out to ascertain the materials used in the kite's construction and library and archival research undertaken to establish the history of the kite's deterioration over the century it has been in the Museum's care.

Maori kite makers fabricated a variety of kites from small, easily made ones of few materials to larger more complicated structures imbued with spiritual power. The accepted general term used for kites is *manu* (bird) followed by a definition, for example, *manu aute*, *manu taratahi*, or *manu kaka* (Best 1976: 122-144).

Kites had a place in several facets of Maori society, ranging from children's games and more serious adult kite flying competitions to playing a role in tribal politics. There are 19th century accounts of kite flying contests involving 20 to 30 men controlling kites soaring at the end of 700 metres of line. Other kites possessed special qualities and could only be flown by men of rank or by priests (Walsh 1912). In times of war, kites were used to divine whether or not to carry out an attack (Cowan 1955:369). Land claims have been made or substantiated because of kites and there are a number of accounts of tribal groups being able to lay claim to the locality their run-away kite fell upon with the reasoning that the kite had invested their mana in the land where it fell (Walsh 1912).

The social changes in New Zealand during the 19th century saw, along with other Maori lifeways, the end of the art of kite making as a popular craft. The birdman kite in the Auckland Museum (Fig.1) is one of two remaining examples of this type of kite in existence, the other is in the British Museum (Fig.2). These kites, known as *manu aute*, were regarded as particularly fine kites because of the way their wings quivered when in flight. They were not high fliers and the length of the line was at best 150-200 m long. Constructed in the mid-1880's the Auckland Museum kite is a superb example of Maori craftsmanship responding to the availability of non-traditional materials in order to create an artefact of pre-European antecedents (Figs.3,4).

Description

The kite has a wingspan of 3.53 m and a body length (from top of head to claws) of 1.27 m. The maximum thickness of its structure rarely exceeds 1 cm, the diameter of

Rec. Auckland Inst. Mus. 24: 67-82 18 December 1987

Fig.1. The Auckland Museum kite, *c.*1890. It was constructed in about 1885 by a kitemaker living in the East Coast region of New Zealand. Photograph: Auckland Institute & Museum

the most substantial structural elements making up the wings and body frame. The kite consists of two components: the mask, and the body and wings.

The body and wing framework is formed from twigs and sticks which create a very strong but lightweight support for the fabric of the kite. Two timbers have been used. The framework is of manuka (*Leptospermum scoparium*) or kanuka (*Kunzea ericoides*), both family Myrtaceae, and the side struts of the upper body and head are of a vine known as supplejack (*Ripogonum scandens*). Sticks range in diameter from 2 to 10 mm. Binding the structure into a single unit are small diagonal lashings of two-ply flax cord at most points where the sticks cross each other at right angles (Fig.5).

The wings are made of 12 longitudinal struts braced at right angles by 45 groups of much thinner sticks. These groups at the wide part of the wing surface close to the body comprise 6-7 parallel twigs *ca.* 3 mm apart. Towards the wingtips the number falls to 4 or 5 twigs per group. At the wingtips further bracing is supplied with two groups of twigs forming a cross formation at 45 degree angles to the other structure (Fig.6). To obtain the 3.53 m wingspan the sticks have been tapered at their ends so that they can be lashed together side by side without thickening the strut.

The body framework consists of 7 vertical running struts running from the curved bottom of the body to the neck area. To shape the structure to which the mask is fixed the manuka or kanuka sticks are substituted in one context with split supplejack. This piece, because of its inherent flexibility forms the upper half of the right hand strut and is bent, first, into the neck, then out and around to form the outline of the head and the other neck indentation before straightening out to become the upper half of the left hand strut of the body (Fig.7). Bracing these vertical struts are groups of thinner sticks identical to those used on the wings. At the bottom of the body two short additional struts have been inserted into the framework to run vertically to the second group of cross struts. Both the wing and body have been partially painted with black and red pigments, the colours alternating with each group of thin struts.

The fabric of the kite consists of two layers. Against the wood framework, using two-ply flax cord, are tied strips of raupo or bullrush leaves (*Typha muelleri*) 2-3 cm wide and, covering these, in effect making the back of the kite, is a plain weave cotton fabric sewn to the frame with linen thread (Fig.8). Along either side of the body from the wing to the feet is a plait of red, yellow and blue wools — now largely missing.

The legs are constructed from a thick plait of New Zealand flax (*Phormium tenax*) which tapers at each end to form the ankles, and this is covered with the cotton textile. The feet are bunched sticks of the kanuka or manuka, each of which is spread to terminate in 4 claws up to 30 mm long covered with red coloured wool (Fig.9).

The face of the kite (Fig.10) is an extremely rare example of Maori mask making. The basic structure of the mask (Fig.11) is made from split supplejack tied with flax cord into a shape upon which the contours of the face could be created. Over this framework were placed pages from an 1884 copy of the New Zealand government gazette, Ko te Kahiti o Niu Tireni, anchored in place with sewing thread (Fig.12). Areas which needed higher contours than the supplejack framework provided were padded out with black coloured cotton wool. These are the cheek-bone areas, the tip of the nose, and the chin. Overlying the newsprint and cotton wool is a sheet of beaten bark fabric. No positive identification has been made except that it has been determined that the bark cloth is not beaten ribbonwood or lacebark (*Hoheria* spp.) which were utilised on occasion in New Zealand. Possibly it is a rare piece of *aute*, the Maori name for bark cloth beaten from the paper mulberry (*Broussonetia papyrifera*). Fixed to this bark cloth surface are the mouth and eye details. These consist of an undetermined tubular core covered with a linen textile which in turn is largely covered with a black coloured flax cord tied into place with half-hitch knots. The eyes are built up from paua shell (*Haliotis iris*) discs but the mouth is sewn directly to the mask.

For cultural reasons, this image has been removed.
Please contact Auckland Museum for more information.

Fig.2. The only other *manu aute* in existence, now in the British Museum, was made sometime before 1843. Photograph: D. Simmons, courtesy British Museum

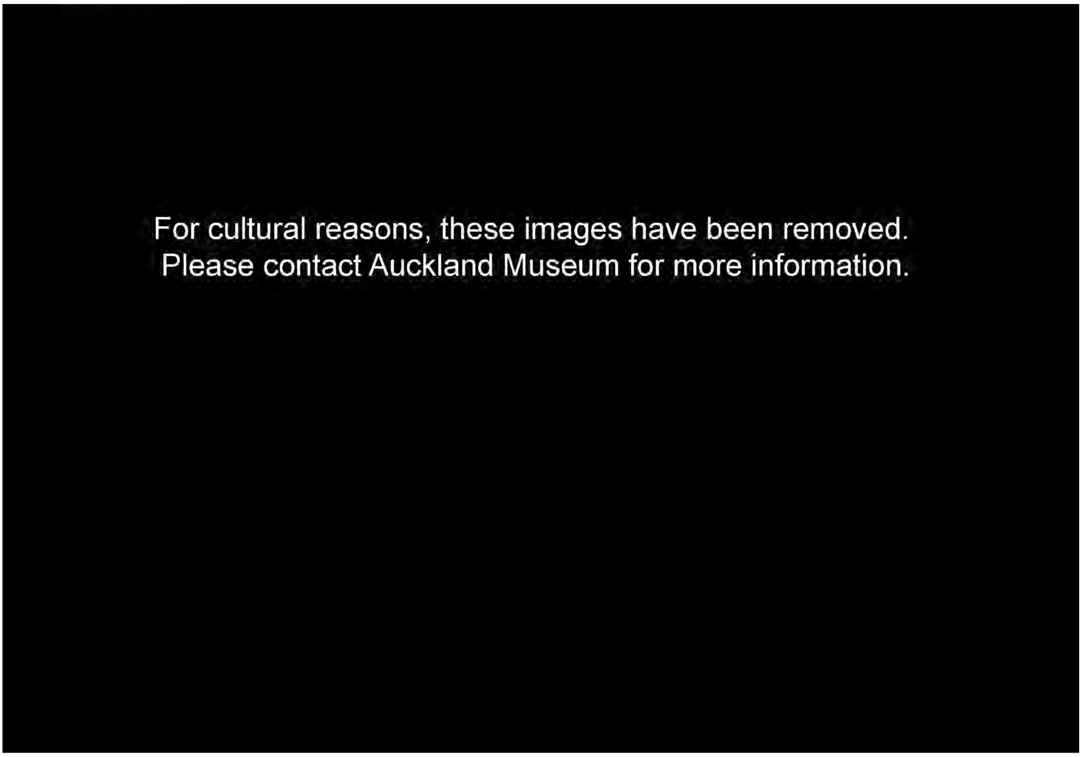

Fig.3. A drawing, dating to 1818, from a page of sketches of Maori kites drawn by Titerree, a Ngapuhi chief who was residing in England at the time. Photograph: Auckland Public Library

Fig.4. This sketch of a *manu aute* was made by the Maori scholar Te Rangi Kaheke in 1859. Photograph: Auckland Public Library

Fig.5. Detail of the wing and body construction of the kite. The parts of the framework which are wrapped in flax cordage for 5-6 cm of their length are the places where the tapered ends of structural members have been joined to make the wing framework.

Fig.6. The wing tip construction.

Fig.7. Detail of the mask mount. The curved edge strut of this area is split supplejack selected for its flexibility. All other bracing and structural wood is kanuka or manuka. The raupo leaf lining under the framework is clearly visible.

History

The kite was made sometime between 1884 and 1886, the year Sir George Grey presented it to the Museum, by a kite maker in the East Coast region of the North Island of New Zealand. The kite was on open display from 1892 until about 1970 when a newly appointed ethnologist, concerned about its appearance, removed it from its sunlit place on the gallery wall to save it from further deterioration. Over these years the kite had undergone several restorations and repairs (Figs.13,14), most of which had disappeared by 1970. One however was of a more permanent nature. In 1929, the right leg for some inexplicable reason was forced out of its original alignment into an inward curve so that the claws pointed roughly towards each other (Fig.9). To keep the leg in its new position a tensioned brass wire 1 mm in diameter was pushed into the leg's flax core. The cotton which covered the leg was then crudely stitched back over the flax. Also by this time the cotton textile had begun to disintegrate about the legs and ankles (Fig.9).

Fig.8. Detail of cotton back to kite showing the stitching holding the textile to the raupo and wood framework.

Fig.9. The condition of the feet and legs in 1984. The misalignment of the kite's right leg (compare with Fig.1) is intentional and dates back to the 1929 "restoration" work.

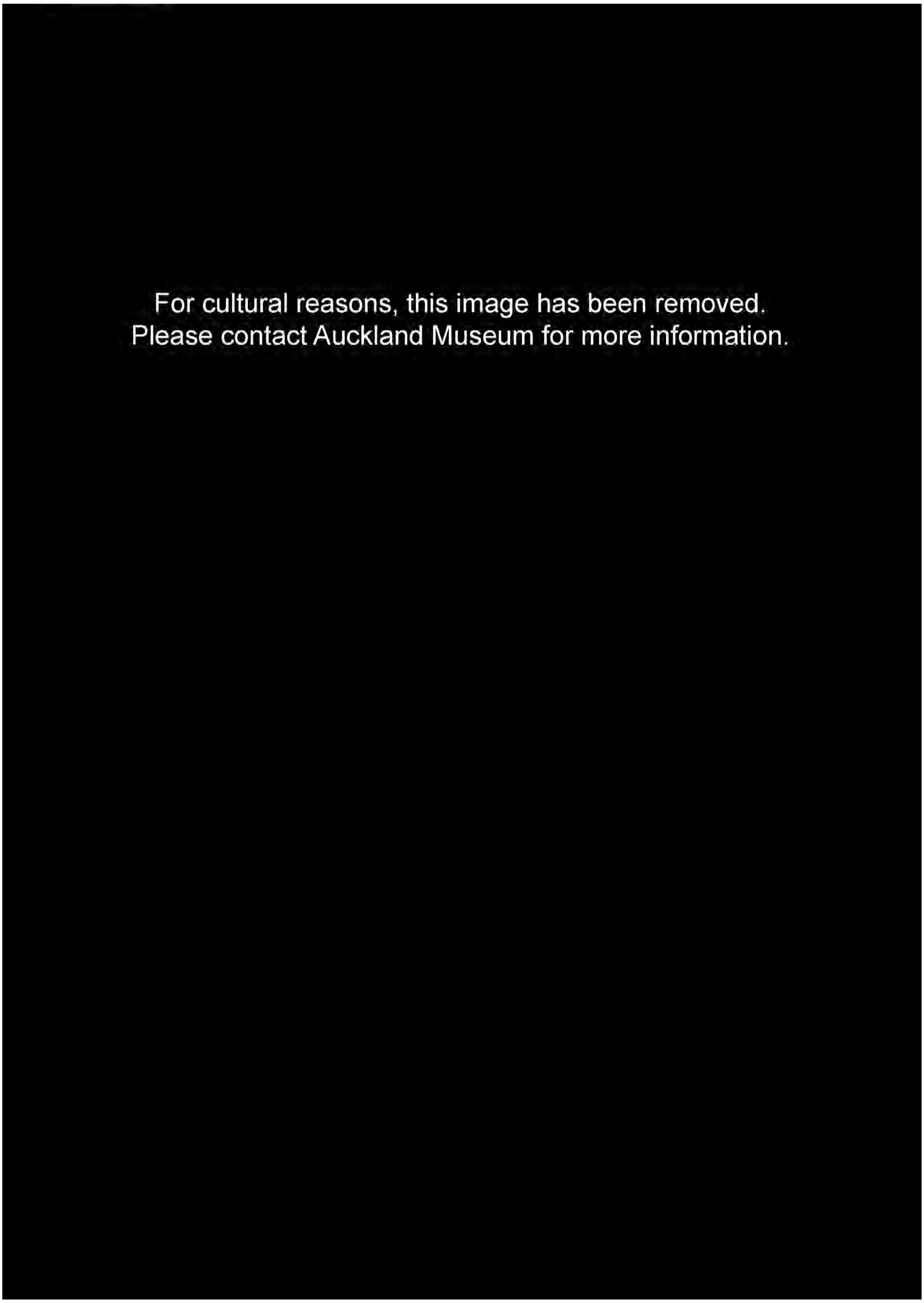

Fig. 10. The mask of the kite as it exists today. Compare with Fig. 1 to see the deterioration its composite materials have undergone in the century since its fabrication.

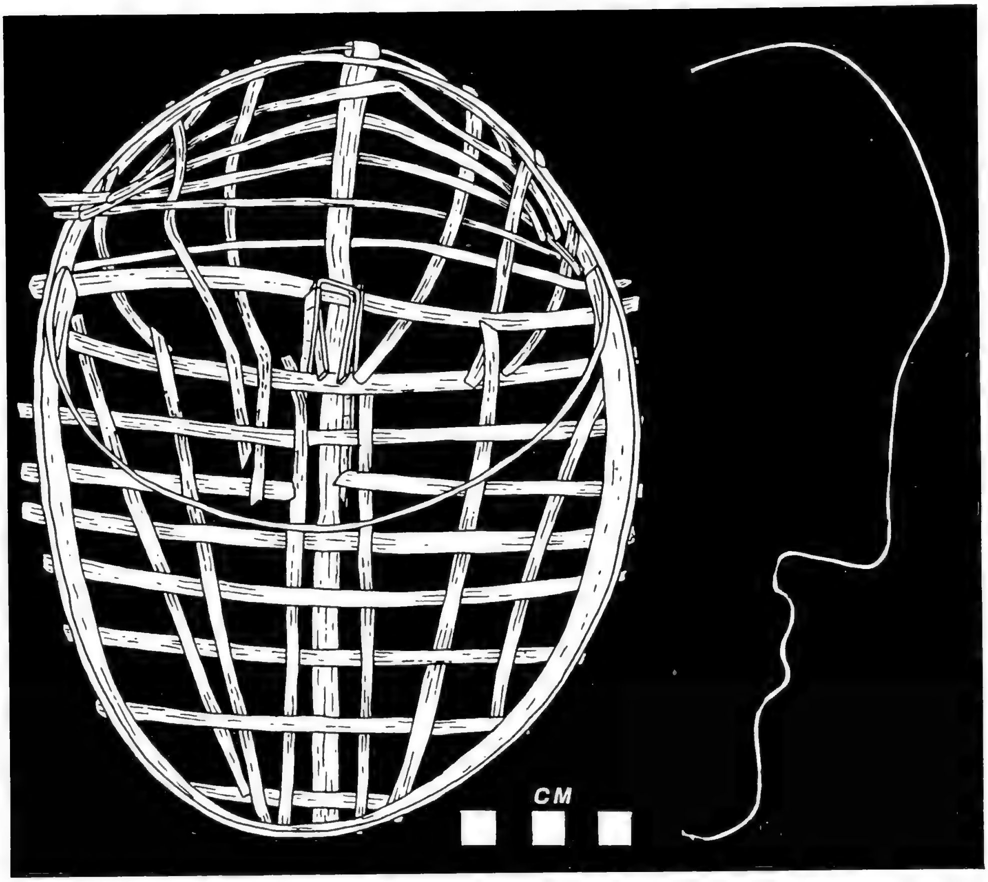

Fig. 11. The mask frame of split supplejack as viewed from behind the face. The profile of the frame is on the right.

A comparison between the 1890's photograph (Fig. 1) and the kite in 1984 shows a number of the losses sustained over the years. With the exception of the missing battens at the feet the losses are all from the mask. Missing is the linen or calico upon which had been painted the moko or facial tattoo and the four, pointed teeth from the mouth. The hair, created by splitting the shafts of flight feathers from the kahu (Australasian harrier, *Circus approximans*) has completely disappeared as have the shark's tooth pendant from the right ear and some sort of collar or wrap about the neck of the figure. In an attempt to preserve the degrading cotton textile and the bark cloth the face and the feet areas were sprayed with polyurethane and the kite placed in storage until 1984 when its conservation commenced.

Fig. 12. A close focus picture of the newsprint covering the supplejack frame of the mask.

Fig. 13. A detail from a photograph of the Prince's Street Museum's Ethnographic Hall *c.* 1905 showing the kite already deteriorating. Note the loss of feather 'hair' and its partial replacement with stiff quills. Photograph: Auckland Institute & Museum

Fig.14. A detail from a photograph published in 1924 showing restoration work on the head. Photograph: National Museum, Wellington

Conservation

The Body. The liberal application of polyurethane had, along with consolidating the textile, fixed its contours into the folds and creases created when the right leg was re-shaped in 1929. It had also bonded the accumulated dust of 4 decades of open display conditions to the textile. The hope was to be able to remove enough of the polyurethane in order to clean some of this dirt and second, re-introduce more flexibility into the textile to enable the alignment of the right leg back into its original position to take place.

Polyurethane resins are created by combining compounds containing two isocyanate (NCO) groups with compounds containing two hydroxyl (OH) groups. The compounds vary between proprietary brands and in the case of the resin sprayed on the kite the compound with the hydroxyl groups is a polyester. Spraying the polyurethane onto the weak cotton fabric subjected the degraded textile to chemical and mechanical damage. The polyurethane used was a moisture curing resin. Its resin curing process involves a reaction between the isocyanate groups and available hydroxyl groups which, promoted by atmospheric moisture and moisture in the substrate to which the

resin is being applied, crosslink to form an impervious amide linkage. When, as in this situation, the substrate is cellulose it is likely that amide links are also formed between the side hydroxyl groups of the cellulose molecules as well as with the polyester (Fig.15). Consequently rather than merely coating the cotton fibres the polyurethane had become an integral part of their structure. Part of the strength of cotton is provided by its water content which gives the fibres their plastic quality. Because any available moisture is used in the crosslinking process of the resin the cotton fibres become dessicated as the resin cures. This results in a loss of flexibility in the fibres at precisely the time they are being subjected to powerful stresses by the curing resin. During the curing a shrinkage in resin volume of 1-2 per cent occurs through crosslinking processes and because of solvent loss. This shrinkage subjects the textile to surface and internal stresses before locking the weave into the resin.

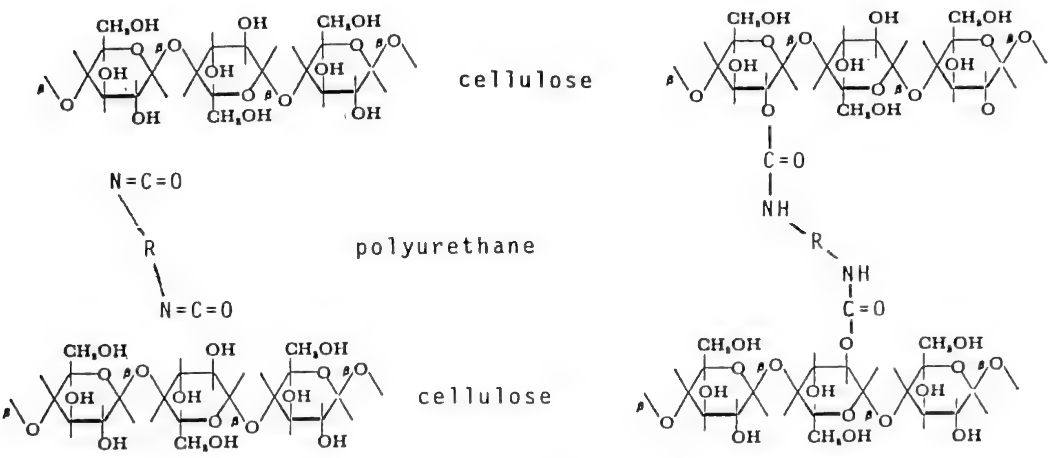

Fig.15. The reaction between cotton fibre and polyurethane resin. Left. Cellulose chains in contact with polyurethane resin. Right. The cellulose chains bonded together into an impervious amide linkage.

By 1984 the resin had aged to the point that the textile was again breaking up. This disintegration was characterized by very brittle fibres which allowed sections of the impregnated cotton to break off from the kite with no physical encouragement other than gravity alone. The polyurethane-cotton because of the above described processes was in a poorer condition than adjacent areas of untreated cotton and consequently removing the resin (in the unlikely event that it was even possible) was out of the question.

It was decided to manipulate the stiff textile as carefully as possible into its original shape and back it with another textile which would provide it with the support it so urgently required. Stitching done in 1929 was unpicked and the aged textile folded away from the legs and ankles of the kite. Carrying out this process inevitably resulted in more of the rigid textile breaking up. The plaited flax legs were re-aligned, severed flax fibres rejoined using PVAcetate emulsion (Promatco A1023) and new strengthening provided by inserting a slender wooden splint into each leg (Fig.16). The backing fabric was then slipped under the original cotton textile. The fabric selected

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Fig.16. The legs and feet after removal of the brass rod and unfolding of the old, polyurethane impregnated cotton textile. To strengthen the legs a thin wooden splint was inserted into the flax plait on both sides.

was a polyester with a similar weave texture and colour to the 19th century cotton. Stitching this to the polyurethane impregnated cotton was impossible as the deteriorated fibres simply snapped with the pressure of the needle and sewing thread. Consequently the polyester was coated with a heat sealing PVAcetate (Mowilith DM44H) diluted to a 1:3 solution and ironed to the cotton.

It was a painstaking task as the frail cotton regularly split, first when being bonded to the polyester, and later when being wrapped about the legs of the kite. This meant tacking and re-tacking small pieces and margins of the cotton to the polyester. Another difficulty encountered was that the quantity of PVAcetate emulsion required to bond the two textiles together gave the polyester a glossy surface. This did not matter where bonding took place but where there were holes in the cotton textile, and where whole pieces of it were missing, the glossy surface of the polyester was exposed. This was eventually minimized by dissolving the Mowilith film with acetone applied with a fine brush and, a few seconds later, blotting the area with absorbent paper.

Other areas of the kite body which required some attention were various broken twigs in the framework, fractured pieces of raupo, and snapped flax fibre lashings. All repairs were bonded with the Promatco A1023.

Up until this point cleaning had been restricted to only areas that needed strengthening in order to avoid handling the kite unnecessarily. Now that the structure was stable it could be cleaned completely. This was carried out using a soft sable brush to lift up dust while simultaneously vacuuming the area under treatment. The efficiency of this method was clearly shown when the grey coloured cotton covering the back of the kite became a buff colour as vacuuming progressed across the back of the kite. On the front care had to be taken with the raupo as the inner membrane of the leaves of this plant which are exposed on the kite are extremely thin and brittle. The fragile nature of the raupo also meant that the obtrusive catalogue number on the body (see Figs.14,16) could not be taken off by mechanical or solvent cleaning. Consequently it was not removed but instead disguised by painting over it with water colours.

The only aqueous cleaning carried out was on the wool covering the claws which were dusty and discoloured. As brushing had proved ineffectual they were washed in a weak detergent solution with some brightening of colour resulting (Hofenk-de Graaff 1968).

The Mask. This was attached to the kite by some large stitches which were judged to date back to the restoration work of 1929. These were cut and the mask removed from the kite. As well as the problems associated with the extremely fragile nature of

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Fig.17. The top of the mask showing one of the several broken supplejack frame members, and the degraded nature of the newsprint and beaten bark cloth.

the ageing newsprint, bark cloth and cotton wool, the mask had also sustained structural damage from insect attack and poor handling. Four supplejack cane struts at the top of the head were snapped and their covering torn suggesting that the head had been crushed and later casually pulled back into shape (Fig.17). These fractures required butt joining. To provide the requisite strength to the joins several layers of Japanese tissue were wound round the break using diluted Promatco A1023 as the adhesive. The dilution varied with the amount of tack needed with each repair.

With structural strength regained the interior and exterior of the mask were cleaned of dust and insect frass by brushing with a soft brush and using a vacuum cleaner. The paua shell eyes were cleaned with acetone applied with cotton wool swabs.

The face of the mask like the legs had earlier received a spray of polyurethane in an attempt to consolidate the disintegrating newsprint, bark cloth and cotton wool. Whatever effect this had once had was now lost and the bark cloth was delaminating. A paste of 2% w/v CMC in water was applied to these areas with a stiff pointed brush. The problem now remained as to what to do with the ragged areas of newsprint and bark cloth on the head. Once these two materials would have completely covered the framework but extensive losses over time had left only patches still in situ, held in place by only the most tenous of links with adjacent pieces. When the mask was removed from the kite a number of pieces were found in the space under the head where they had fallen inwards over the years and there were enough to warrant an attempt to partially re-cover the head. This was done by spreading one piece of Stabiltex over a ball of tissue paper the same size as the head cavity. The mask was placed over this, the loose fragments of newsprint and bark cloth laid on top, and then a second piece of Stabiltex spread over the whole head — in effect sandwiching the fragments. By passing a curved sewing needle through the framework where no paper or bark cloth lay the bottom piece of Stabiltex was then hooked up by the needle and drawn towards the upper piece by the sewing thread. The thread was then knotted. The final effect was one of rather rough quilting with all the loose original material securely anchored between the almost transparent Stabiltex. Lastly a small amount of trimming and tailoring was done to make the stabiltex as unobtrusive as possible.

Conclusion

This project emphasizes the importance of ethnographic conservators being closely involved with curatorial research when looking at conservation requirements of artefacts under their care. At Auckland Museum the conservators are encouraged to carry out such research as part of condition reporting. In the case of the kite this policy resulted in an interesting situation for, as more information about the kite's history came to light, there developed an almost inverse ratio between the research and plans for actual treatment: more of the former and less and less of the latter as the project progressed. At the outset of this project the curatorial directive was to restore the kite to its 1890's appearance but by the completion of the project 2 years later the kite had only been stabilized to its existing condition. Instead a replica of the most damaged part of the kite, the mask, is being created in order to show how the kite originally appeared. This is a far more satisfactory plan although one not particularly apparent before the research was carried out.

Acknowledgements. I would like to thank Dave Simmons, former Ethnologist, and Mick Pendergrast, Ethnology Assistant, Auckland Museum for their insights and enthusiasm about Maori kites; Anthony Wright, Botanist, Auckland Museum for plant identification; Sabine Weik, Conservator, for practical assistance and professional advice; and Gary Brett and Dr Terry Lomax for advice about polyurethane.

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NEW AND INTERESTING RECORDS OF ADVENTIVE PLANTS FROM THE AUCKLAND INSTITUTE AND MUSEUM HERBARIUM 12

E.B. BANGERTER

AUCKLAND INSTITUTE AND MUSEUM

Abstract. This twelfth list of additions to the Auckland Institute and Museum Herbarium (AK) by exchange or by presentation from collectors provides new records for some adventive species and further information on the distribution of others.

The main source of material for this twelfth list has been by exchange with Botany Division, D.S.I.R., Christchurch (CHR) or by the acquisition of voucher specimens from the Botany Department, University of Auckland (AKU). In particular, voucher specimens have been presented by Mr A.E. Esler, D.S.I.R., Auckland.

The nomenclature adopted in this paper follows that of the series of checklists published in the *New Zealand Journal of Botany* from 1978 onwards by members of the staff at Botany Division, D.S.I.R., Christchurch, for dicotyledons, or that of volume 3 of the *Flora of New Zealand* by Healy & Edgar (1980) for monocotyledons.

All specimens are cited by the AK number and by the collectors' numbers where these are provided. Unless otherwise stated the specimens may be regarded as the only naturalised material of the species possessed by the Herbarium and, where no previous literature is cited, as first records for New Zealand to the best of my knowledge at the time of writing.

FUMARIACEAE

Corydalis lutea (L.) DC.

Stratford Co., Douglas, Taranaki, waste ground at edge of stream, 1956, R. Mason 4244, AK 163155 (dupl.ex CHR 91043).

This duplicate from CHR is the sole representative of yellow fumitory in the AK Herbarium. The locality is included in the distribution published by Garnock-Jones (1979), where the first record is stated to be in Smith (1904). In spite of the plant's long occurrence in this country it is still noted as "rare and local".

BRASSICACEAE

Arabidopsis thaliana (L.) Heynh.

Nelson, south branch Motueka River mouth, roadside verge 1985, A.J. Watson, AK 173764, det. P.Champion, (dupl.ex Waikato Technical Institute Herbarium No. 493); Waitemata Co., Browns Bay, Palmers' carpark, 1986, E.B. Bangerter 5556, AK 175624.

These two gatherings, the former presented by the Waikato Technical Institute, have been added to the one recorded by Bangerter (1975). It is noted simply as a "weed". Garnock-Jones (1979) does not include Nelson in the distribution of wall-cress. The second gathering above has the note "rare in *Antirrhinum* bed with *Coronopus didymus*, *Cardamine hirsuta* and *Spergula arvensis*".

Brassica juncea (L.) Czern.

Whangarei Co., Mimiwhangata, Rimariki Island, north-western coast, 1981, A.E. Wright 4467, AK 156140; A.E. Wright 4469, AK 156141; A.E. Wright 4463, AK 156149. (All three specimens collected on the same day).

The first record for this species is in Garnock-Jones (1979) where Northland is included in the distribution. Cameron (1984) cites a specimen from Lady Alice Island in the Herbarium of Auckland University (AKU 12538).

Sisymbrium altissimum L.

Vincent Co., Otago, Earnscleugh, 1984, F.A. Meeklah, AK 173080, det. P.J. Garnock-Jones, (dupl.ex CHR 417244); Vincent Co., Cromwell, 1936, H.H. Allan, AK 66603, det. A.J. Healy 1957.

Although often recorded since 1870, tumbling mustard is represented in the AK Herbarium only by the two gatherings above. The earlier one is noted as a "roadside weed" whilst the later is recorded as "common" in a "newly planted orchard". The locality of these two specimens is covered by the distribution in Garnock-Jones (1979).

CARYOPHYLLACEAE

Silene vulgaris (Moench) Garcke ssp. *vulgaris*

Southland, Riverton, south side of Jacobs River estuary on highway 99, 1982, D.R. Given 13174 & H.K. Hall, AK 174804, (dupl.ex CHR 403712); Waitemata Co., Milford, Wolsey Road, roadside, 1985, E.B. Bangerter 5554, AK 170804.

The first gathering above was acquired by exchange from CHR as authentic material from the South Island. A note with the specimen says "scattered patches up to

1 m across, 50 cm tall". The second gathering is from the Auckland area, not given by Garnock-Jones (1981) in the distribution of this bladder-campion and considered rare by A.E. Esler. The habitat note says "few plants on roadside verge among garden outcasts with *Trifolium repens* and *Sonchus oleraceus*". There are three other gatherings in AK and several records in the literature.

GERANIACEAE

Erodium botrys (Cav.) Bertol.

Central Otago, near lucerne paddocks, 1985, F.A. Meeklah & M. Turner, AK 176280, det. W.R. Sykes, (dupl.ex CHR 421023).

Long storksbill is listed in Healy (1984) as "not known in the wild state in New Zealand". It is therefore not included in Sykes (1982). A note with the specimen above says "specimens come from several localities".

BALSAMINACEAE

Impatiens sodenii Engl.

Waitemata Co., Waitakere Tramline, 1978, C. Soulje, AK 155261; Bay of Islands Co., Motuarohia Island, 1980, R.E. Beever 80107, AK 156792. Both specimens det. A.E. Wright 1984.

The latter of the two specimens above is a voucher for the record in Beever, Esler & Wright (1984). The other completes the representation of this species in the AK Herbarium. Sykes (1982) gives its distribution, which includes Wellington as well as Auckland, and attributes the first record to Healy (1958). The distribution is extended further to the eastern North Island by Heginbotham & Esler (1985) who describe the species as "horticultural plants growing in semi-wild state".

MYRTACEAE

Angophora costata (Gaertn.) Druce

Auckland City, Wisely Road, from tree in Williams Road, Hobsonville, 1985, A.E. Esler, AK 173110.

I am indebted to Mr W.R. Sykes for the correct authorities for this species. The gathering was kindly presented by Mr A.E. Esler, who notes on the label "naturalised in scrubland now being developed for housing; some trees being left for landscaping". In a letter accompanying the specimen Mr Esler says "probably the first collection in New Zealand as a wild plant".

MALVACEAE

Abutilon theophrasti Medik.

Manukau Co., Papakura, Dominion Road, 1983, G.M. Hood, AK 170745, det. A.E. Esler.

This is the second specimen of this plant in the AK Herbarium. A note on the label reads "appeared in garden — suspected from fowl wheat". Webb (1981) records "known from Ararimu and Lincoln only".

EUPHORBIACEAE

Euphorbia characias L.

Auckland City, Mt. Wellington, 1985, A.E. Esler, AK 173111, det. A.E. Esler.

This is the only specimen of Wulfen spurge in the AK Herbarium and extends northward the distribution as given in Webb (1981). A note with the gathering says "locally plentiful as a naturalised plant with grass in woodland."

GROSSULARIACEAE

Ribes sanguineum Pursh.

Lake Co., Queenstown Hill, 1982, W.R. Sykes 160/82, AK 176216 (dupl.ex CHR 400829).

Although well recorded and according to Given (1948b) with a wide distribution from south of the North Island to the South and Stewart Islands, flowering currant is represented in the AK Herbarium by only the above specimen. The habitat is shown as "*Pseudotsuga* plantation, rather open part near track". Following a detailed description is the comment "A common adventive species".

ROSACEAE

Potentilla recta L.

Otago, between Waipiata and Kokonga on Kokonga Road, 1984, D.R. Given 13549 & C. Frampton, AK 176218 (dupl.ex CHR 416252).

In spite of the fact that tall cinquefoil has been recorded a number of times this is the only naturalised adventive specimen in the AK Herbarium. The habitat is

"roadside, dry but with tall grasses and forbs" and it is "common in grassland". Given (1982) records its distribution as Marlborough, Canterbury and Otago.

UMBELLIFERAE

Apium graveolens L.

Three Kings Group, Great Island, 1983, A.E. Wright 6078, AK 173008-9, det. A.E. Wright 1986. (dupl. sent to CHR).

This is a recent addition to the AK Herbarium which otherwise possesses two old specimens in Herb.Cheeseman. Further information on the label says "growing in seepage area on cliffs 100 m S.E. of Tasman Stream Waterfall. Originally planted by fishermen? Now abundantly naturalised". In Webb (1978) the distribution of wild celery is given as South Auckland and Canterbury.

COMPOSITAE

Dahlia coccinea Cav. X. *D.pinnata* Cav.

Christchurch, Hornby, waste land — old shingle pit (Smarts Pit), 1966, A.J. Healy 66/217, AK 173096, det. C.J. Webb 1985 (dup.ex CHR 172723); Waitemata Co., Waitakere Range, Waiatarua, 1981, J. Mackinder, AK 155014, det. C.J. Webb 1986.

These two specimens determined by Dr Webb represent this hybrid dahlia in the AK Herbarium. The former, acquired by exchange from DSIR Christchurch, is noted as a "persistent garden outcast". The latter presented to AK by the collector is described as "3 stems growing beside the road, one in flower".

Dahlia excelsa Benth.

Port Nelson, Tahunanui, 1974, A.J. Healy 74/75, AK 173053-4, det. C.J. Webb 1985 (dupl.ex CHR 234981); Auckland City, Sandringham Road below railway line and opposite Walters Road, 1984, E.K. Cameron 2922, AK 171364, (dupl.ex AKU 16191); Auckland City, Auckland Domain, gully opposite intersection of Titoki Street and Domain Drive, 1974, J.H. Goulding 587 & E.B. Bangerter, AK 134651.

The first of these gatherings of the tree-dahlia is from the original locality of the first record in Given (1984a). It is described as "stems to 5 m tall, inner phyllaries appressed ± hyaline ± shining. Ray florets ±8. Also in other Nelson localities." The second is "3-4 m tall, large pink flowerheads, covering an area ± 20 x 80 m". The third collected by Miss Jeanne Goulding and myself is from a "clump c3 m tall".

Tagetes minuta L.

Piako Co., Walton, maize paddock, 1981, P.B. Heap, AK 163008, det. C.E. Ecroyd, (dupl.ex NZFRI 11051).

This specimen of Mexican marigold from the herbarium of the Forest Research Institute at Rotorua is the only one in the AK Herbarium. Distribution of the species is in Given (1984a). Esler (1978) records "not seen in Manawatu". The height of the plant is stated as "up to 1 m high".

BORAGINACEAE

Cynoglossum amabile Stapf & Drumm.

Rodney Co., north of Kaukapakapa and Helensville, 1985, K. Wood, AK 176176, det. A.E. Esler.

The Chinese forget-me-not was first recorded growing wild in 1975 according to Sykes (1981b), who states that it is "a rare escape from cultivation". Notes with the specimen give a more detailed location as "scattered along about 2 chains beside newly sealed portion of Highway 16 between Glorit Hall and south entrance road to Mt. Auckland walkway". The habitat "growing in heavy clay" and colour of flowers "deep blue".

SCROPHULARIACEAE

Veronica scutellata L.

Lake Wairarapa, near old channel of Ruamahanga River, 1983, C.C. Ogle 974, AK 167407, det. B.H. Macmillan, (dupl. ex CHR 404623).

This duplicate from CHR Herbarium is the first example of marsh speedwell in the AK Herbarium, although it has been recorded in the literature several times. The habitat note on the label says "growing in ungrazed swampy pasture among *Carex lessoniana*". Distribution may be found in Sykes (1981a).

SOLANACEAE

Cestrum aurantiacum Lindl.

North Cape Co., beside Tapotupotu Bay, by estuary, 1984, E.K. Cameron 2812, AK 171357 (dupl.ex AKU 15955).

Distribution for orange cestrum is in Sykes (1981b), covering a large part of the northern half of the North Island. The above gathering, acquired by exchange from the University of Auckland's Herbarium is the only example in the AK Herbarium of the species as a wild plant. Further information on the label reads "plants 1-2m tall, locally abundant under kanuka/manuka".

BUTOMACEAE

Hydrocleys nymphoides (Humb. & Bonpl.) Buchenau

Rodney Co., Kaipara, Tauhoa, 1985, D. Armstrong, AK 170718, det. A.E. Esler.

This water poppy was sent to Mr A.E. Esler for identification by the Ministry of Agriculture and Fisheries and presented by him to the AK Herbarium. A note with the specimen reads "farm dam with *Myriophyllum aquaticum*". Two other sheets AK 95116-7 from the original gathering, Te Aroha, by Cheeseman are in the Herbarium, part of the first collection as cited in Healy & Edgar (1980), who also comment on the plant's aggressive spread.

LILIACEAE

Asparagus sprengeri Regel

Auckland Domain, lower slopes, 1983, E.K. Cameron 2283, AK 163048, det. A.E. Wright, (dupl.ex AKU 14942).

This duplicate from the AKU Herbarium adds another sheet to the two recorded in Bangerter (1982). This species of *Asparagus* does not appear in Healy & Edgar (1980) but is described by Esler (1984). A note with the specimen above says "roadside bank ±climbing. Pl. ± 1.5 m long possesses spines".

Lilium formosanum A. Wallace

Waitemata Co., Waitakere Range, Scenic Drive, Waiatarua, 1980, J. Mackinder, AK 154848; Coromandel Co., Coromandel Peninsula, Cooks Beach, 1984, K. Mays, AK 170721, det. A.E. Wright 1985.

These are the only specimens of this lily in the AK Herbarium, first recorded by Healy and Edgar (1980) as from Whakatane in 1972. A habitat note with the latter specimen says "growing profusely along the beach-front reserves and for several kms along the roadside approaches".

IRIDACEAE

Gladiolus byzantinus Miller

Auckland City, Grafton, banks of southern motorway adjacent to Grafton Road overbridge, 1982, A.E. Wright 5176, AK 162169; Auckland City, Great South Road, near Remuera Railway Station, 1984, R.O. Gardner, 4402, AK 171961, det. A.E. Wright 1986.

A note in Healy & Edgar (1980) says that this species was recorded in 1870 by Kirk but no specimens have been seen since. These authors give a detailed description of this distinctive gladiolus. Notes with the above gatherings concur. The former were "growing amongst shrubs and unmown grasses on motorway margins". The flowers were "crimson-purple with a white stripe along the middle of each of the three lower petals". The latter were "three plants together in dry grass" with "petals various shades of iridescent mauve, the lowest one with a central stripe".

Gladiolus nanus Andr.

Waitemata Co., Waitakere Range, Cornwallis Road, 1985, J. Mackinder, AK 176511, det. A.E. Wright 1987; Waitemata Co., Glen Eden, Waikumete Cemetery, 1986, A.E. Esler, AK 176485, det. A.E. Esler.

This species is not recorded in Healy & Edgar (1980). Habitat for the former is "In long grass, roadside". For the latter it is "naturalised in rough grass among graves".

Ixia paniculata Delaroche

Waitemata Co., Glen Eden, Waikumete Cemetery, 1986, A.E. Esler AK 176484, det. A.E. Esler.

Mr Esler's gathering was made from the same locality and in the same habitat as *Gladiolus nanus*. The species is noted in Healy & Edgar (1980) as having been collected only once, in 1972 on Muriwai Road, Auckland, which is also in Waitemata Co., towards the west coast.

Acknowledgements. I am again much indebted to Mr A.E. Wright, Botanist at this Museum for continued encouragement and for the provision of several voucher specimens. My thanks are due to the staff of Botany Division, D.S.I.R., Christchurch, particularly for the acquisition of specimens of rare or local adventives. To Mr A.E. Esler, D.S.I.R., Auckland I am also grateful for supplying voucher specimens for new records and for most helpful correspondence concerning adventives in the Auckland area. Mr E.K. Cameron, Mr J. Mackinder and Dr R.O. Gardner have provided material for which I am also most grateful.

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TYPE SPECIMENS OF PACIFIC MOLLUSCA DESCRIBED MAINLY BY A. GARRETT AND W. PEASE

WITH DESCRIPTION OF A NEW *Morula* SPECIES (MOLLUSCA:GASTROPODA)

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Abstract. The type specimens of *Engina gibbosa* Garrett, *Latirus granulosus* Pease, *Engina ovata* Pease, *Sistrum squamosum* Pease, *Engina variabilis* Pease, *Engina nodulosa* Pease, and *Gibbula affinis* Garrett, have been examined. Lectotypes have been designated and the species re-assigned to their appropriate families and synonymy. The species *Morula angulata* (Sowerby), *Gibbula affinis* var. *cognata* Pilsbry, and *Clanculus danieli* Crosse, have also been examined and the lectotypes are illustrated and discussed. The species known to date under the homonymous name "*Morula parva* (Pease)" is here described as *M.parvissima* sp.n.

William Harper Pease (1824-1871), a native of Brooklyn, New York, and a surveyor by profession, took up residence in Honolulu, the capital of the Hawaiian Islands in 1849. He rarely ventured outside of Hawaii and depended on other collectors for specimens collected in other parts of the Pacific. One such collector who later became Pease's friend, was Andrew Garrett (1823-1887), a native of Albany, New York and an iron moulder by trade and sailor by choice, who arrived in Honolulu in 1847. Garrett travelled widely throughout the Pacific and collected the flora and fauna of various island groups whenever the opportunity arose. He discovered many new molluscan species which he described in American and British malacological Journals. He also supplied Pease with many species which were later on described by Pease in the *Proceedings of the Zoological Society of London* and the *American Journal of Malacology*.

Pease's molluscan type-specimens can be found in the British Museum (Nat.Hist.), London, the Academy of Natural Sciences, Philadelphia, and the Museum of Comparative Zoology, Harvard University. Type-specimens of molluscan species described by Garrett are housed in the Bernice P. Bishop Museum, Honolulu, and several types are also in the Academy of Natural Sciences, Philadelphia. Garrett also acted as collector for the German shipping firm J.C. Godeffroy & Son, and he despatched numerous lots of shells with many types among them, to the Zoological Museum in Hamburg. These type-specimens were destroyed during bombing raids on Hamburg during the second world war, but some types may also have become lost during a shipwreck after Garrett's departure from Fiji.

Rec. Auckland Inst. Mus. 24: 93-105 18 December 1987

Kay (1965) published a report on Pease's molluscan type-specimens housed in the British Museum (Nat.Hist.), London. A biography and bibliography of W.H. Pease together with a catalogue of names proposed by Pease has been published by Kay & Clench (1975). A biography of A. Garrett has been compiled by Thomas (1979) and a catalogue of molluscan species described by Garrett has been published by Clench (1979).

Family BUCCINIDAE

Genus **Cantharus** Röding, 1798

Cantharus Röding, 1798, Mus.Bolten. p.132. Type species by SD (Cossmann, 1901) *Buccinum tranquebaricum* Gmelin, 1791. Recent, Indian Ocean.

Subgenus **Clivipollia** Iredale, 1929

Clivipollia Iredale, 1929, Austral.Zoologist 5(4):347. Type species by M *C.imperita* Iredale, 1929 = *Ricinula pulchra* Reeve, 1846. Recent, Indo-Pacific.

Cantharus (Clivipollia) recurvus (Reeve, 1846) (Figs.1-4)

1846. *Ricinula recurva* Reeve, Conch.Icon. 3:pl.6,fig.53.
1872. *Engina gibbosa* Garrett, Proc.Calif.Acad.Sci. 4:203.
1975. *Cantharus* (*Clivipollia*) *recurva* (Reeve), Cernohorsky, Rec. Auckland Inst.Mus. 12:205, figs.67,68 (figd.syntype).

TYPE LOCALITY. Lord Hoods I [= S.Marutea I, S.E.end of the Tuamotu Archipelago] (*recurva*); Viti [Fiji] and Samoa Is (*gibbosa*).

Type specimens. Two syntypes of *R.recurva* Reeve, are in the British Museum (Nat.Hist.), London (for further details see Cernohorsky 1975). Seven syntypes of *E.gibbosa* Garrett from the Samoa Is, are in the Bernice P. Bishop Museum, Honolulu, No.1669, and four syntypes of *E.gibbosa* from the Fiji Is are in the Academy of Natural Sciences, Philadelphia No. 34534. The larger specimen from the Samoan Is, now in the Bernice P.Bishop Museum, Honolulu, length 9.7 mm, width 5.3 mm, height of aperture 5.2 mm, is here selected as the lectotype of *E.gibbosa* Garrett. The lectotype has 6¼ whorls of the teleoconch and a protoconch of 1¼ embryonic whorls, the shell is sculptured with prominent wavy spiral cords, the outer lip has a denticle bordering the anal canal and is followed by 5 denticles, the narrowly calloused columella has 5 denticles at the margin, 1 parietal denticle and a "split tooth" deeper within; the shell is orange-brown and spiral cords whitish (Figs.1,2). The syntype from the Fiji Is measures length 7.7 mm, width 4.5 mm (Figs.3,4).

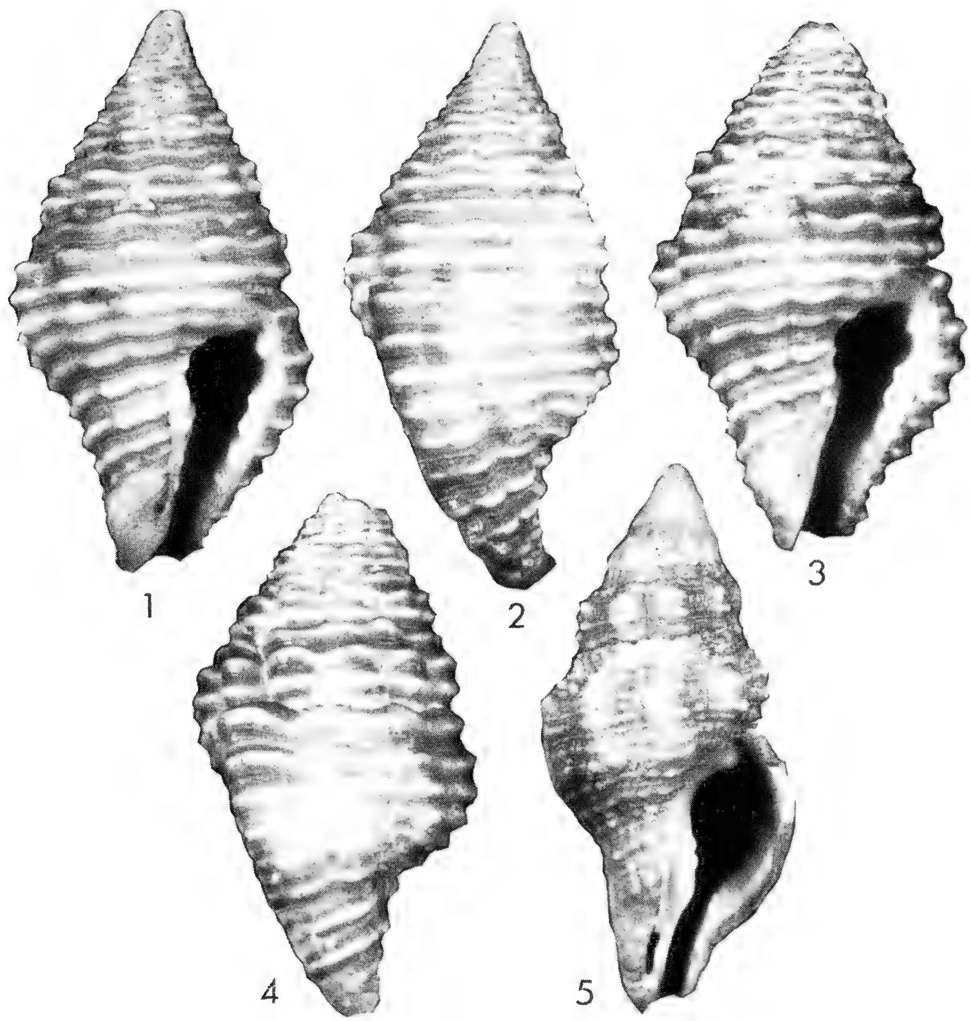
Engina gibbosa Garrett, 1872, is a synonym of *Cantharus* (*Clivipollia*) *recurvus* (Reeve, 1846).

Cantharus (Clivipollia) albocinctus (Pease, 1860) (Figs. 6,7)

1860 *Engina albocincta* Pease, Proc.Zool.Soc.Lond. p.142; 1965 Kay, Bull.Brit.Mus. (Nat.Hist.),Zool.Suppl. 1:16,pl.2,figs.9,10 (figd. lectotype); 1979 Kay, Hawaiian Mar.shells p.263, fig.92F.

1975. *Cantharus* (*Clivipollia*) *albocinctus* (Pease), Cernohorsky, Rec.Auckland Inst.Mus. 12:207,fig.70 (figd. lectotype).

TYPE LOCALITY. Hawaiian Is.



Figs. 1-5. 1-4 *Cantharus* (*Clivipollia*) *recurvus* (Reeve). 1,2. Lectotype of *Engina gibbosa* Garrett, Samoa Is; BPBM No.1669, 9.7 mm. 3,4. Paralectotype of *E.gibbosa* Garrett, Fiji Is; ANSP No.34534, 7.7 mm. 5. *Latirus granulosus* Pease, Tuamotu Archipelago; MCZ No.261181, 23.6 mm.

Type specimens. The lectotype of *C.* (*C.*) *albocinctus* (Pease), is in the British Museum (Nat.Hist.), London, No.1961454 (for further details see Kay, 1965 and Cernohorsky, 1975).

The species was previously known by illustrations of the faded lectotype or worn and faded specimens. A fresh, live-taken specimen has been collected at Faaone, Tahiti (*leg.* J.Trondle), length 7.3 mm, width 3.6 mm. The specimen has 5¼ mature whorls and a protoconch of 3 smooth, rose-coloured embryonic whorls; the shell is dark reddish-brown with a white median band and occasional pale spots on cords (Figs.6,7).

Genus **Engina** Gray, 1839

Engina Gray, 1839, Zool.Capt.Beechy's voy."Blossom", p.112. Type species by SD (Gray,1847) *E.zonata* Gray, 1839 = *Purpura turbinella* Kiener, 1836. Recent, Caribbean.

Engina ovata Pease, 1865 (Figs.8,9)

1865. *Engina ovata* Pease, Proc.Zool.Soc.Lond. p.513; 1868 Pease, Americ.J.Conch. 3(4):274,pl.23,fig.6.
1883. *Engina funiculata* Reeve (pars), Tryon, Man.Conch. 5:194,pl.62,fig.48 only (non *Ricinula funiculata* Reeve, 1846).

TYPE LOCALITY. Island of the central Pacific (Pease 1865); Howland I (Pease 1868).

Type specimens. The holotype of *Engina ovata* Pease, is in the Academy of Natural Sciences, Philadelphia, No. 34536, *ex*-Pease collection, length 11.5 mm, width 6.3 mm. There are 5½ whorls inclusive of the protoconch, each whorl with a blackish-brown row of nodules at sutures and a pinkish band in between, the body whorl with 9 rows of nodules. The outer lip has a denticle bordering the anal canal, followed by 4 strong denticles, the columella with 8 denticulate lirae. The nodulose spiral cords are black, interspaces pinkish-white and edge of aperture light violet with a brown stain on columella (Figs.8,9).

On the label accompanying the holotype of *Engina ovata* is a note (appended by Tryon ?) = *E.funiculata* Reeve. The types of *Ricinula funiculata* Reeve, 1846 (see Cernohorsky, 1975, fig. 74) although superficially similar in colouring to *Engina ovata*, are worn specimens of a *Morula*, family Muricidae. *Morula funiculata* is different in shape, the columella lacks the denticulate lirae and prominent swelling, and the denticles on the outer lip are smaller and more numerous.

Family FASCIOLARIIDAE

Subfamily PERISTERNIINAE

Genus **Latirus** Montfort, 1810

Latirus Montfort, 1810, Conchyl.Syst. 2:531. Type species by OD *L.aurantiacus* Montfort, 1810 = *Murex gibbulus* Gmelin, 1791. Recent, Indo-Pacific.

Latirus granulosus Pease, 1868 (Fig.5)

1868. *Latirus granulosus* Pease, Americ.J.Conch. 3(4):279,pl.23,fig.10 (fig.18 in error).
1881. *Peristernia granulosa* (Pease), Tryon, Man.Conch. 3:86,pl.66,fig.105; 1933 Dautzenberg & Bouge, J.Conchyl. 77:202.

TYPE LOCALITY. Paumotus [= Tuamotu Archipelago, French Polynesia].

Type specimens. Four syntypes of *L.granulosus* Pease, are in the Museum of Comparative Zoology, Harvard University, Cambridge No. MCZ-261181, *ex*- Pease collection (Marked "paratypes"). The specimen illustrated by Pease (1868), dimensions length 23.6 mm, width 10.7 mm, is here selected as the lectotype of *L.granulosus* Pease. The lectotype has *c.* 6 whorls, 9 axial ribs on the penultimate and 9 on the body whorl, 9 granulose spiral cords + 2-3 nodes on the penultimate and 24 spiral cords on the body whorl; aperture is violet and lirate within, columella with 3 small folds and a parietal denticle and the colour is orange-brown with the granules a paler colour (Fig.5).

Family MURICIDAE

Subfamily THAIDINAE

Genus **Morula** Schumacher, 1817

Morula Schumacher, 1817, Essai nouv.syst. pp.68,227. Type species by M *M.papillosa* Schumacher, 1817 = Drupa uva Röding, 1798. Recent, Indo-Pacific.

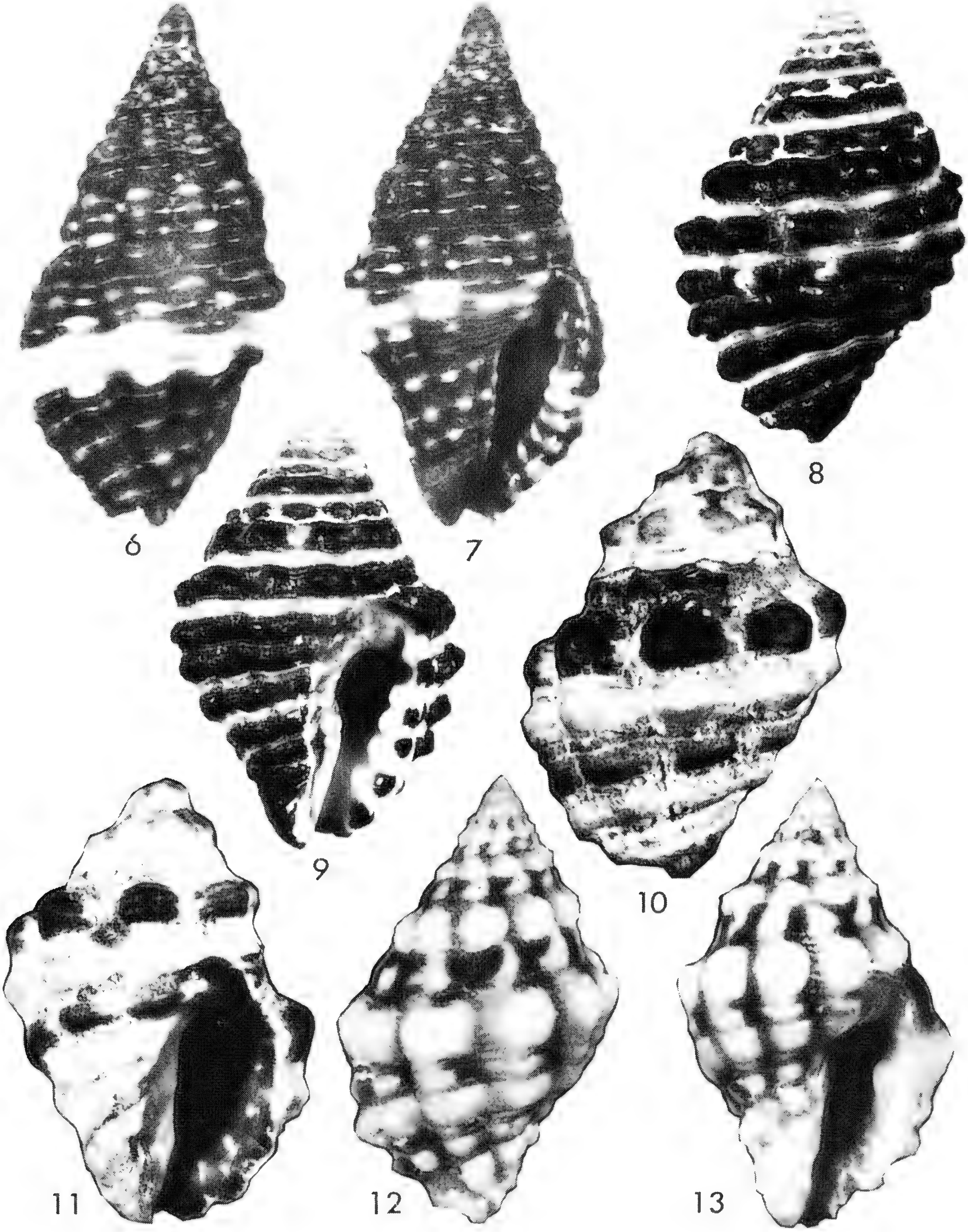
Morula marginatra (Blainville, 1832) (Figs.10,11)

1832. *Purpura marginatra* Blainville, Nouv.Ann.Mus.Hist.Nat.Paris 1:218,pl.10,fig.1.
1836. *Purpura cancellata* Kiener, Spéc.gén.icon,coq.viv. 8:25,pl.17,fig.16 (ref. to Blainville, 1832, pl.10,fig.1) [non Quoy & Gaimard, 1833].
1868. *Sistrum squamosum* Pease, Americ.J.Conch. 3(4):277,pl.23,fig.14.

TYPE LOCALITY. Tycopia, New Hebrides [= Ticopia, Solomon Is] (*marginatra* and *cancellata*); Kingsmill Is [= southern Kiribati Is] (*squamosum*).

Type specimens. Three syntypes of *Sistrum squamosum* Pease, are in the Academy of Natural Sciences, Philadelphia No. 29910, *ex*-Pease coll. The illustrated syntype, which is here designated as the lectotype of *S.squamosum* Pease, measures length 11.5 mm, width 8.0 mm. The shell is dull with a lamellose sculpture, coarse brown and white nodes, a brown aperture, 4 paler denticles on the outer lip and 2 weak folds on the columella (Figs.10,11).

S.squamosum Pease, 1868, is a synonym of *Morula marginatra* (Blainville, 1832). A label accompanying the syntypes of *S.squamosum* reads " = *marginatra* Blainville".



Figs. 6-13. 6,7 *Cantharus* (*Clivipollia*) *albocinctus* (Pease). Faaone, Tahiti; 7.3 mm. 8,9. *Engina ovata* Pease. Holotype from Howland I, ANSP No.34536; 11.5 mm. 10,11. *Morula marginatra* (Blainville). Lectotype of *Sistrum squamosum* Pease from Ticopia I, Solomon Is; ANSP No. 29910, 11.5 mm. 12,13. *Morula variabilis* (Pease). Lectotype from Tuamotu Archipelago; MCZ No.260618, 7.0 mm.

Morula variabilis (Pease, 1868) (Figs.12,13)

1868. *Engina variabilis* Pease, Americ.J.Conch. 3(4):275pl.23, fig.9; 1933 Dautzenberg & Bouge, J.Conchyl. 77:210.

TYPE LOCALITY. Paumotus [= Tuamotu Archipelago, French Polynesia].

Type specimens. Three syntypes of *M.variabilis* (Pease) are in the Museum of Comparative Zoology, Harvard University, Cambridge No. MCZ-260618, *ex*-Pease coll. The syntype measuring length 7.0 mm, width 4.4 mm, is here selected as the lectotype of *M.variabilis* (Pease). The lectotype has 4 mature whorls and a conical protoconch of 4 smooth embryonic whorls. There are 9 nodose axial ribs and 4 spiral rows of nodes on the body whorl and additional intermediate spiral cords; the outer lip is thick with 4 denticles; the aperture is purplish-violet, and the nodes pinkish-white with dark brown interspaces. (Figs.12,13).

Tryon (1883) considers *Engina variabilis* to be a synonym of *E.nodicostata* described by Pease (1868) one page earlier. However, Dautzenberg & Bouge (1933) insist that *Morula variabilis* is a good species and they cite several Polynesian localities where the species has been collected.

Morula parvissima sp. n. (Figs.14,15)

1868. *Engina parva* Pease, Americ.J.Conch. 3(4):276,pl.23,fig.11; 1883 Tryon, Man.Conch. 5:195,pl.653,fig.55; 1933 Dautzenberg &Bouge, J.Conchyl. 77:209; 1967 Orr-Maes, Proc.Acad.Nat.Sci.Philadelphia 119:135,pl.12,fig.G; 1986 Springsteen & Leobrera, Shells Philippines p.140,pl.38,fig.7 (non *Ricinula parva* Reeve, 1846 = *Morula*).

1978. *"Morula parva"* (Pease), Cernohorsky, Rec.Auckland Inst.Mus. 15:77,figs.24,25 (illustrated paratypes of *M.parvissima*).

Shell up to 6.2 mm in length, solid, elongate-biconic, width 48-56% of shell-length, teleoconch of 3-3¼ whorls, conical protoconch of 3¼ + (incomplete in specimens examined) smooth, glassy embryonic whorls. Whorls sculptured with prominent nodules arranged on 9-10 axial ribs on penultimate and 7-9 ribs on body whorl; penultimate whorls with 2 spiral rows and body whorl with 6 spiral rows of nodules, white nodules larger than blackish ones. Under magnification numerous fine, minutely beaded spiral striae can be seen to cover surface. Aperture narrow, outer lip thickened and with 4 denticles, third anterior denticle always the smallest, columella narrowly calloused and with 1-2 minute denticles anteriorly, anal and siphonal canals distinct. Ornamented with alternating rows of white to pinkish-white and blackish-brown nodules, calloused siphonal fasciole with oblique brown streaks, edge of outer lip with 3 blackish spots, base of columella stained brown, blackish-brown colouring of nodules usually extending on to parietal wall.

TYPE LOCALITY. Mururoa Atoll, Tuamotu Archipelago.

DISTRIBUTION. From the Tuamotu Archipelago to the Philippines and the Cocos-Keeling Is, Indian Ocean.

Holotype. In the Auckland Institute and Museum No.TM-1374, length 5.6 mm, width 2.9 mm (Figs.14,15).

Paratypes. Several paratypes from the type locality and Faaone, Tahiti, Society Is, in coll.C.Beslu, Tahiti, and J.Trondle, La Force, France. Paratypes have also been illustrated by Cernohorsky (1978, figs.24,25).

It has already been pointed out (Cernohorsky 1978) that "*Engina parva*" Pease, 1868, is a secondary homonym of *Ricinula parva* Reeve, 1846, and that the species certainly does not belong to the genus *Engina* Gray, family Buccinidae, but to *Morula* Schumacher, family Muricidae. Four syntypes of *Engina parva* Pease, are in the Academy of Natural Sciences, Philadelphia No. 34542, *ex*-Pease coll. All four syntypes are greatly worn and faded and almost useless for identification purposes. To complicate matters, Pease (1868) described his *Engina parva* as "nodules on upper part of last whorl produced into spines, whole surface scabrous or wrinkled". There is no evidence whatsoever of either spines or scabrous surface in either the greatly worn syntypes or Pease's original type-figure which looks in considerably better condition than any of the existing syntypes (Figs.16-18). The only features associating the worn syntypes with fresh specimens of *parvissima* are the alternate rows of blackish-brown and white nodules and the 4 denticles on the outer lip, the third anterior denticle being the smallest.

It is for this reason that *M.parvissima* has been described as a new species with a clearly recognizable holotype and paratypes rather than being proposed as a substitute name for *Engina parva* Pease with its worn type specimens and conflicting description.

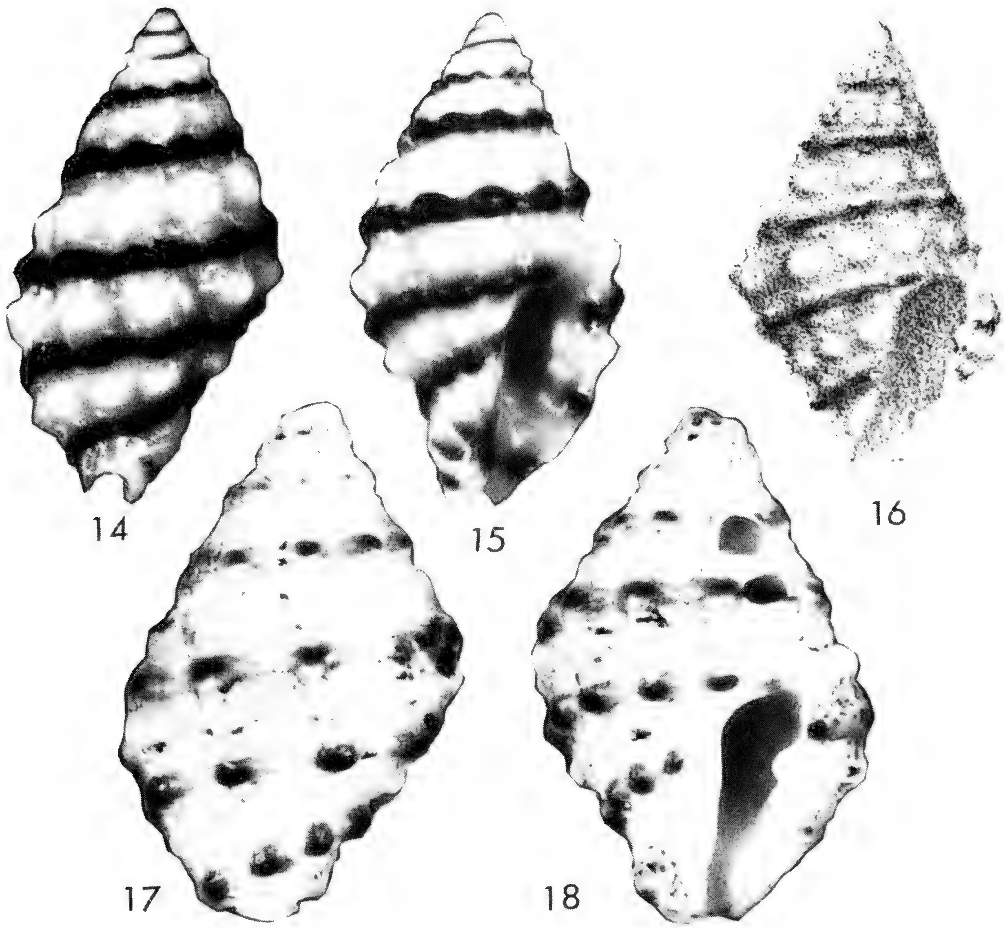
Morula angulata (Sowerby, 1893) (Figs. 19-21)

1893. *Sistrum angulatum* Sowerby, Proc.Malac.Soc.Lond. 1:46, pl.4,fig.3.

TYPE LOCALITY. Mauritius.

Type specimens. The holotype of *Sistrum angulatum* Sowerby, is in the British Museum (Nat.Hist.), London, No.1902.11.26.72., length 6.4 mm, width 4.7 mm. The holotype is worn and faded, has 5 remaining whorls, 2 spiral rows of nodules on upper spire whorls and 8 on the body whorl, 4 denticles on the outer lip and 3 small denticles on the anterior of the columella; brown colouring is visible on some echinate nodes (Fig.19).

The species is sympatric with *M.parvissima* at Mururoa Atoll, Tuamotus (*leg.* C.Beslu). Fresh specimens are biconic, the teleoconch consists of 3 whorls and the conical protoconch of 3½ glassy, smooth embryonic whorls; the shell is sculptured with alternating rows of orange-yellow and dark purple or purple-brown nodules, the latter being more echinate than the former. The surface is distinctly scabrous, and under magnification axial foliations and numerous spiral striae are visible; the outer lip has 4 denticles and the anterior of the columella 1-2 denticles. The size range is 5.5 — 6.0 mm (Figs.20,21).



Figs. 14-18. 14,15. *Morula parvissima* sp.n. Mururoa Atoll, Tuamotu Archipelago. Holotype AIM No.TM-1374, 5.6 mm. 16-18. *"Engina" parva* Pease. 16. Type-figure (from Pease, 1868, pl.23, fig.11). 17,18. Syntype from Tuamotus, ANSP No.34542, 5.7 mm.

Genus **Cronia** H. & A. Adams, 1853

Cronia H. & A. Adams, 1853, Gen.Rec.Moll. 1:128. Type species by M *Purpura amygdala* Kiener, 1835. Recent, Indo-Pacific.

Subgenus **Ergalatax** Iredale, 1931

Ergalatax Iredale, 1931, Rec.Austral.Mus. 18(4):231,233. Type species by OD *E.recurrens* Iredale, 1931 = *Buccinum contractum* Reeve, 1846. Recent, Indo-Pacific.

Cronia (Ergalatax) nodulosa (Pease, 1869) (Figs.22,23)

1869. *Engina nodulosa* Pease, Americ.J.Conch. 5(2):71,pl.8,fig.11; 1883 Tryon, Man.Conch. 5:189,pl.69,fig.10.

TYPE LOCALITY. Ebon I, Marshall Is.

Type specimens. The holotype of *Engina nodulosa* Pease, is in the Academy of Natural Sciences, Philadelphia, No.34513, *ex*-Pease coll. The holotype measures length 16.2 mm, width 8.0 mm, and has 5 whorls and a worn protoconch. There are 8 axial ribs and 2 main spiral cords on the penultimate and 8 axial ribs and 5 main spiral cords on the body whorl, the area between main spiral cords is sculptured with finer spiral threads, and there are 6 denticles on the outer lip and a smooth columella. The shell is brown in colour with a white median band (Figs.22,23).

Pease (1869) described the species as "blackish, last whorl encircled by a whitish band", but the holotype has obviously faded to brown. The species has not been reported in recent malacological literature.

Family TROCHIDAE

Genus **Gibbula** Risso, 1826

Gibbula Risso, 1826, Hist.Nat.l'europ.merid. 4:134. Type species by SD (Herrmannsen, 1847) *Trochus magus* Linnaeus, 1758. Recent, Mediterranean.

Subgenus **Eurytrochus** Fischer in Kiener, 1879

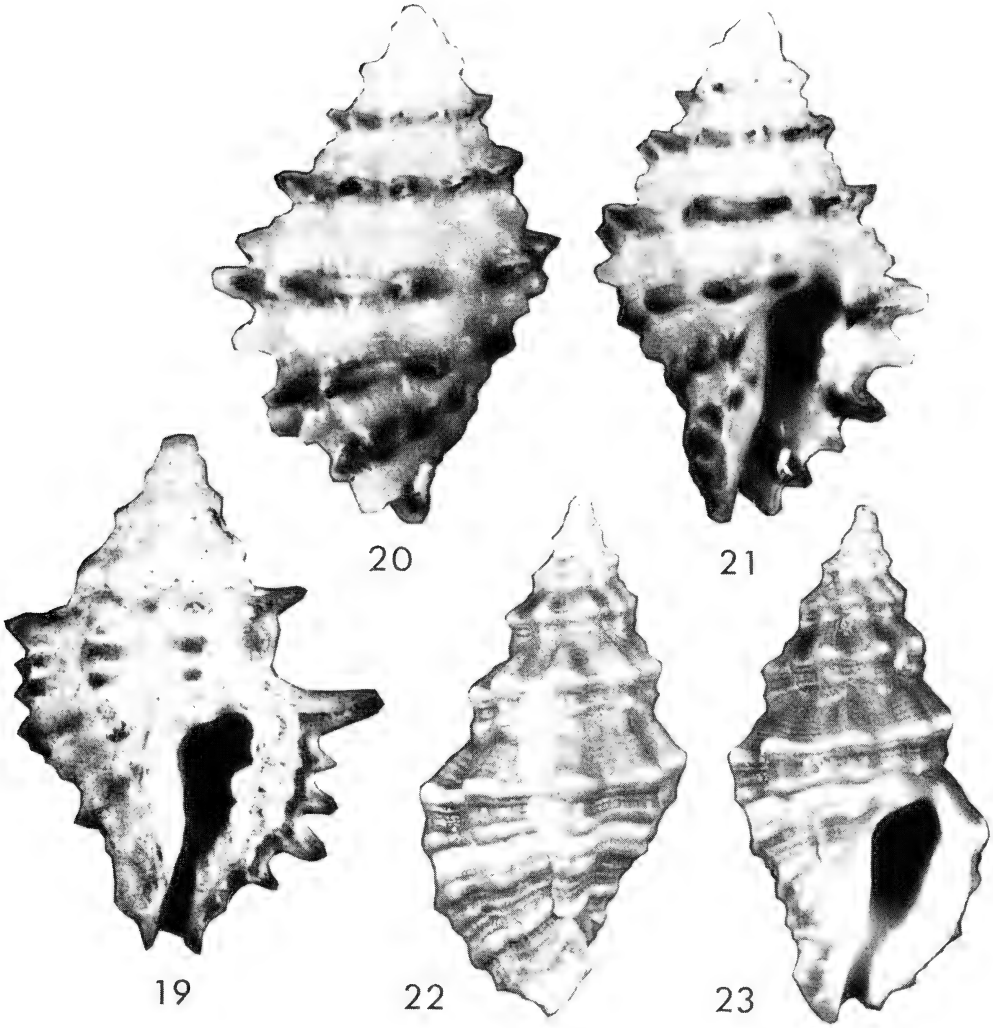
Eurytrochus Fischer in Kiener, 1879, Spéc.gén.icon.coq.viv. 11:417. Type species by SD (Pilsbry, 1889) *Clanculus danieli* Crosse, 1862. Recent, West Pacific.

Gibbula (Eurytrochus) affinis Garrett, 1872 (Figs.24-29)

1872. *Gibbula affinis* Garrett, Proc.Calif.Acad.Sci. 4:201; 1889 Pilsbry, Man.Conch. 11:230,pl.40,fig.6,7.
1903. *Gibbula affinis* var. *cognata* Pilsbry, Nautilus 17(6):69.
1964. *Eurytrochus affinis cognatus* (Pilsbry), Habe, Shells west. Pacific col. 2:11,pl.4,fig.17.

TYPE LOCALITY. Viti [= Fiji] and Samoa Is (*affinis*); Riukiu I [= Ryukyu Is, Japan] (*cognatus*).

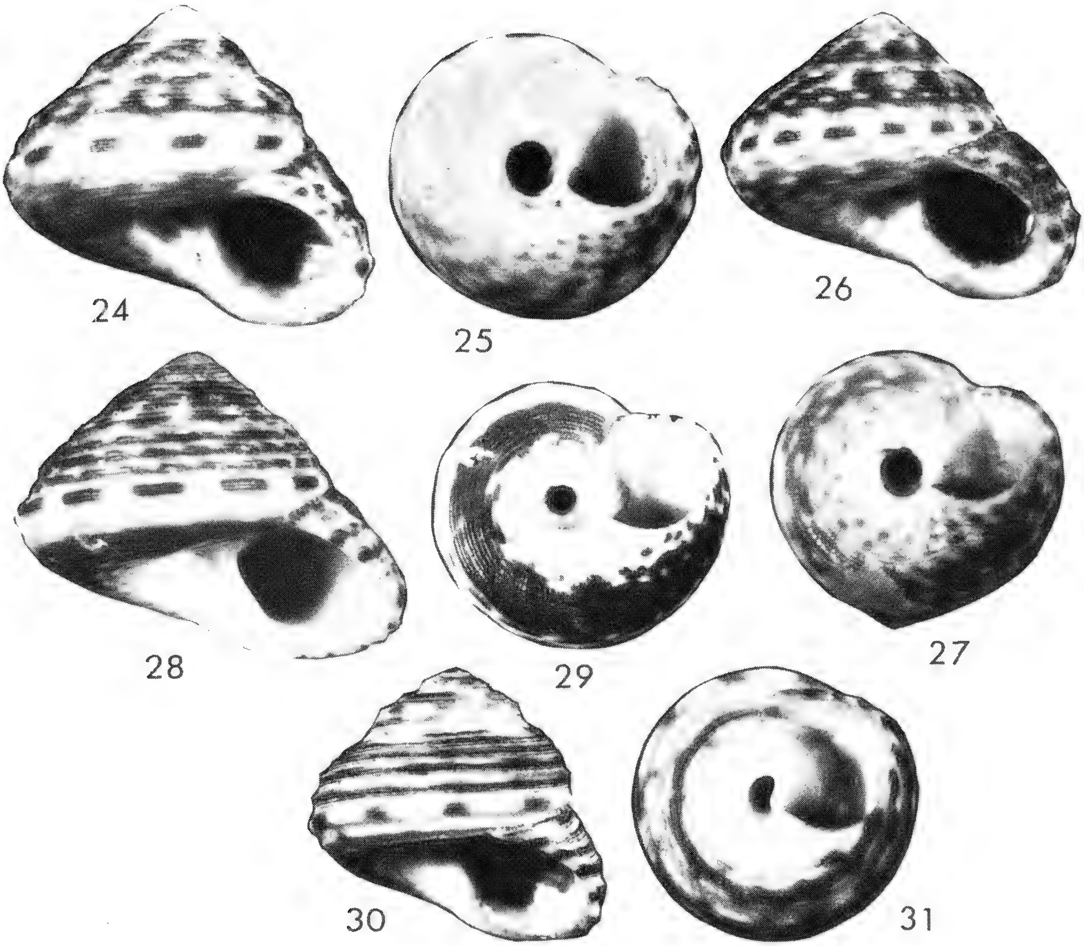
Type specimens. Four syntypes of *Gibbula affinis* Garrett, are in the Academy of Natural Sciences, Philadelphia, No.48679. The syntype measuring width 6.3 mm, height 5.5 mm, is here selected as the lectotype (Figs.24,25). The species has *c.* 5½-6 whorls inclusive of protoconch, 5-6 minutely beaded spiral cords on the penultimate whorl and some very fine intermediate striae, the interspaces between spiral cords with extremely fine, oblique striae. There is a roundly angulate periphery with a stronger cord and base with *c.* 9 cords which flatten out towards the umbilicus which has a



Figs. 19-23. 19-21. *Morula angulata* (Sowerby). 19. Holotype from Mauritius, B.M.(N.H.) No.1902.11.26.72., 6.4 mm. 20,21. Specimen from M ururoa Atoll, Tuamotu Archipelago; 5.9 mm. 22,23. *Cronia* (*Ergalatax*) *nodulosa* (Pease). Ebon I, Marshall Is; Holotype ANSP No.34513, 16.2 mm.

strong cord entering the interior. The colouring consists of dark greenish-brown maculations on a cream-coloured background. Other syntypes are in the Bernice P. Bishop Museum, Honolulu, No.2273, and the illustrated syntype, width 6.6 mm, height 5.6 mm, is complete with operculum, which is circular, corneous, multispiral with a central nucleus (Figs.26,27).

Four syntypes of *G.affinis* var. *cognata* Pilsbry, are also in the Academy of Natural Sciences, Philadelphia, No.82038. This Ryukyu form differs from typical



Figs. 24-31. 24-29. *Gibbula* (*Eurytrochus*) *affinis* Garrett. 24,25. Lectotype from the Fiji Is, ANSP No.48679; 6.3 mm. 26,27. Paralectotype from the Samoa Is, BPBM No.2273; 6.6 mm. 28,29. Lectotype of *G.* (*E.*) *affinis* var. *cognata* Pilsbry, Ryukyu Is, ANSP No.82038; 6.8 mm. 30,31. Lectotype of *G.* (*E.*) *danieli* (Crosse), New Caledonia, MNHNP (no number); 6.3 mm.

affinis in the wider-spaced spiral cords. The illustrated syntype, width 6.8 mm, height 4.8 mm, is here selected as the lectotype of *G.affinis* var. *cognata* Pilsbry (Figs.28,29).

Three syntypes of *Clanculus danieli* Crosse, 1862, from New Caledonia, the type-species of the subgenus *Eurytrochus* Fisher in Kiener, are in the Muséum National d'Histoire Naturelle, Paris (no number). The syntype measuring width 6.3 mm, height 5.8 mm, is here selected as the lectotype of *Clanculus danieli* Crosse. The lectotype has 3 whorls, a protoconch of 2 embryonic whorls and a sculpture consisting of spiral cords and intermediate macrosculpture; aperture nacreous (Figs.30,31).

Acknowledgements. I would like to express my thanks to Dr R. Robertson, Academy of Natural Sciences, Philadelphia, and Dr K. Boss, Museum of Comparative Zoology, Harvard University, Cambridge, for the loan of type material from their collections. I am grateful to Mr J. Trondle, La Force, France, and Mr C. Beslu, Papeete, Tahiti, for material collected in the Tuamotu and Society Islands.

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THE TAXONOMY OF SOME INDO-PACIFIC MOLLUSCA

PART 14. WITH DESCRIPTIONS OF TWO NEW SPECIES

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Abstract. Phos naucratoros Watson, *P.hirasei* Sowerby, *P.nigroliratus* Habe, *P.elegantissimus* Hayashi & Habe, and *P.* cf. *borneensis* Sowerby, are new geographical records from the Philippines and *Nassarius oneratus* (Deshayes), *N.multicostatus* (A. Adams), *Scabricola vicdani* Cernohorsky, *Hastula anomala* (Gray), *Lophiotoma kingae* Powell and *Conus consors* Sowerby, are new geographical records from the Fiji Islands. *Latirus martinorum* sp.n., a deep-water fasciolarid from the Philippines and *Terebra bratcherae* sp.n., a terebrid from West Australia, are described as new species. The radulae and metapodial tentacles of *Nassarius gibbosulus* (Linnaeus) and *N.circumcinctus* (A.Adams) are compared, and the species *Vexillum (Costellaria) verecundulum* (Hervier) is elucidated on the basis of a live-taken specimen. The authorship of the family-group name Litiopidae is credited to Gray, 1847, instead of Fischer, 1885.

Family BUCCINIDAE

Genus **Phos** Montfort, 1810

Phos Montfort, 1810, Conchyl.Syst. 2:495. Type species by OD *Murex senticosus* Linnaeus, 1758. Recent, Indo-Pacific.

Phos naucratoros Watson, 1882 (Fig.1)

1882. *Phos naucratoros* Watson, J.Linn.Soc.Lond.Zool. 16:360; 1977 Cernohorsky, Rec.Auckland Inst.Mus. 14:127,figs.17,18 (illustrated holotype).
1886. *Phos naucratoris* (sic) Watson, Rept.Sci.Res.Voy.H.M.S. "Challenger" 15:218, pl.13,figs.11a-c.

TYPE LOCALITY. Admiralty I, Papua New Guinea, 150 fathoms (275 m).

Cernohorsky (1977) illustrated the holotype of *P.naucratoros* and reported the species from off Cape Moreton, Queensland, Australia. The range is now extended to the Philippine Is, where specimens have been dredged at Balicasag I, Bohol, in tangle nets, 183-275 m, Punta Engano, Mactan I, Cebu (both *ex*-coll. V.Dan) and off Coamen I, western Bohol reef, in 190-230 m (*leg.* R.Martin).

Rec. Auckland Inst. Mus. 24: 107-122 18 December 1987

Phos hirasei Sowerby, 1913 (Figs.2,3)

1913. *Phos hirasei* Sowerby, Ann.Mag.Nat.Hist. (8), 11:558,pl.9,fig.2; 1972 Okutani, Bull.Tokai Reg.Fish.Lab. No.72:93, textfig.38; 1978 Cernohorsky, Rec.Auckland Inst.Mus. 15:55,figs.1,2 (illustrated holotype).

TYPE LOCALITY. Kii, Japan.

Cernohorsky (1978) illustrated the holotype of *P.hirasei* and reported the species from the Kermadec Is. Specimens have recently been trawled in the Philippines, at Balicasag I, Bohol, in tangle nets, 183-275 m, Punta Engano, Mactan I, Cebu (both *ex*-coll.V.Dan) and off Coamen I, western Bohol reef, in 190-230 m (*leg.* R.Martin). The number of axial ribs varies greatly, and in some specimens 27 axial ribs on the body whorl have been counted.

Phos nigroliratus Habe, 1961 (Fig.4)

1961. *Phos nigroliratum* Habe, Col.illust.shells Japan 2:61,App.p.21,pl.31,fig.9.

TYPE LOCALITY. Off Isshiki-cho, Hazu-gun, Aichi Pref., Honshu, Japan, 100 m.

This species is now recorded from off Coamen I, western Bohol reef, Philippines, in 190-230 m (*leg.* R.Martin). The species is similar in colouring to *P.elegantissimus* Hayashi & Habe, 1965, but is less inflated with narrowly chanelled sutures and axial ribs which extend above the sutures.

Phos elegantissimus Hayashi and Habe, 1965 (Fig.5)

1965. *Phos elegantissimus* Hayashi & Habe, Venus:Jap.J.Malac. 24(1):11,14,pl.1,fig.4; 1972 Okutani, Bull.Tokai Reg.Fish.Res.Lab. No.72:93,fig.40.

TYPE LOCALITY. Enshu Nada, off Honshu, 100-120 m.

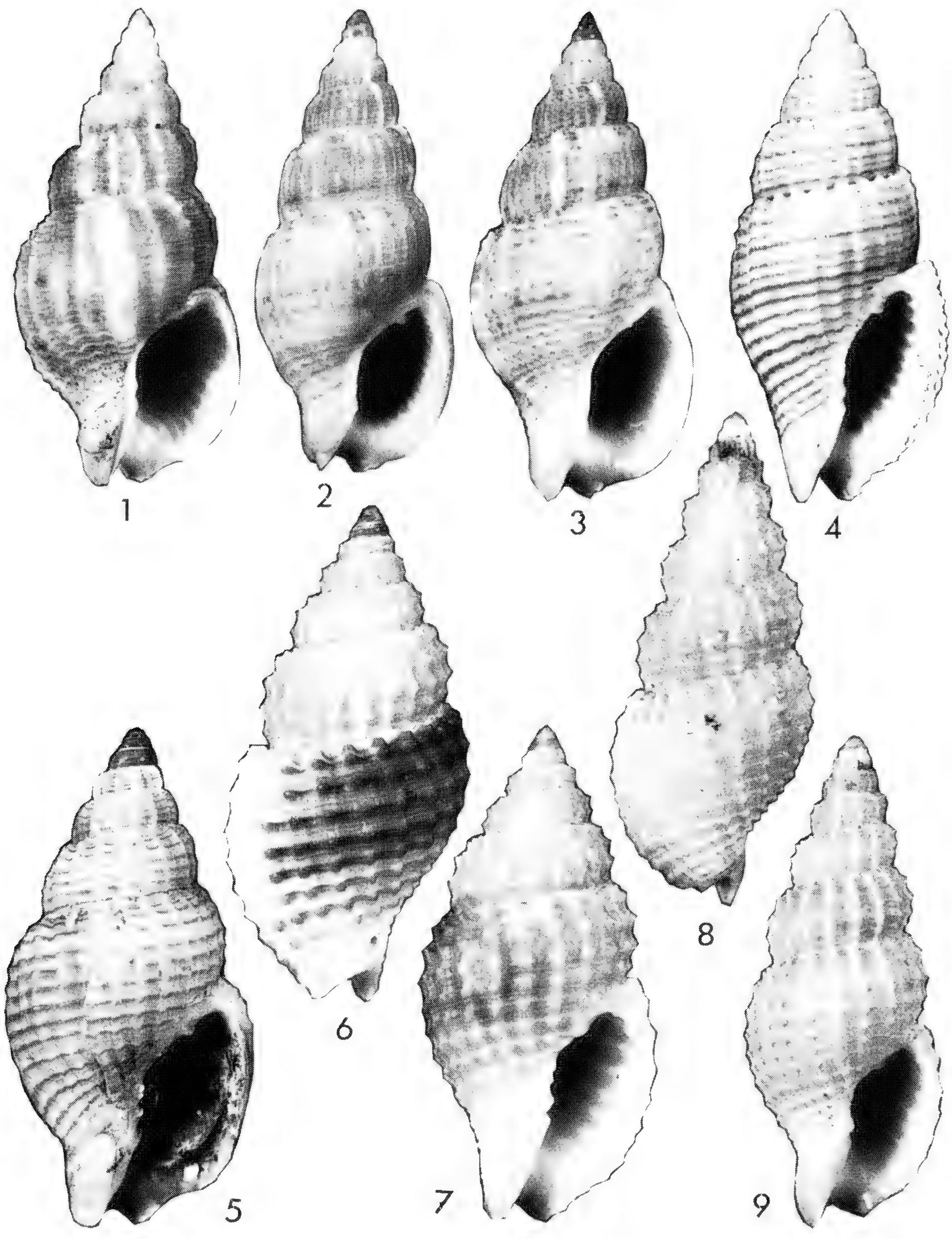
The species' range now extends to the Philippines, where it has been dredged off Coamen I, western Bohol reef, in 190-230 m (*leg.* R.Martin).

Phos cf. **borneensis** Sowerby, 1859 (Figs.6,7)

1859. *Phos borneensis* Sowerby, Thes.Conchyl. 3(19):91,pl.222,fig.22.

TYPE LOCALITY. Borneo [Indonesia].

Type specimen. Not found. The holotype of *P.borneensis* originally in the Cuming collection has as yet not been located in the British Museum (Nat.Hist.), London (K.Way *in litt.* 26/11/1986).



Figs. 1-9. 1. *Phos naucratoros* Watson. Off Coamen I, Philippines, 190-230 m; 28.3 mm. 2,3. *P.hirasei* Sowerby. Same locality. 2. 27.5 mm. 3. Broad form, 25.2 mm. 4. *P.nigroliratus* Habe. Same locality; 17.7 mm. 5. *P.elegantissimus* Hayashi & Habe. Same locality; 18.0 mm. 6,7. *P.* cf. *borneensis* Sowerby. Same locality; 16.2 mm. 8,9. *P.bathyketes* Watson. Holotype from the Philippine Is, B.M.(N.H.) No. 1887.2.9.750.; 22.5 mm.

A single specimen tentatively associated with *P.borneensis* has been dredged at Coamen I, western Bohol reef, Philippines, in 190-230 m (*leg.* R. Martin). The shell is 16.3 mm in length, with convex whorls which are regularly sculptured with axial ribs which bear regularly spaced nodules, and interspaces carry 2-3 fine intermediate spiral striae; the protoconch is multispiral with the last half turn bearing arcuate axial ribs and 3 fine spiral cords, the outer lip has 9 strong lirae and the columella 2 main folds + 2 smaller posterior denticles + 1 parietal denticle and the outer lip ends in a very broad varix. The shell is white with the dorsal side of the body whorl stained orange-brown (Figs.6,7).

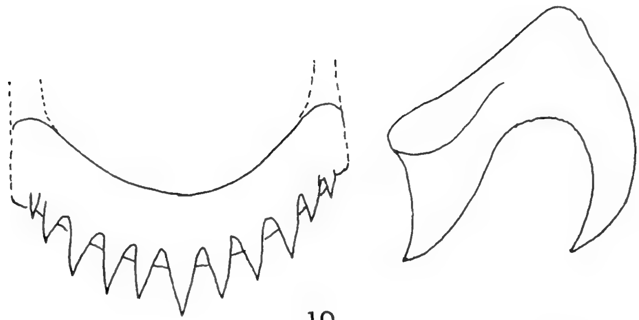
Watson (1882) described a *Phos bathyketes* from the Philippine Is, and in his description he compared his new species with *P.borneensis* Sowerby. The holotype of *P.bathyketes* is in the British Museum (Nat.Hist.), London No.1887.2.9.750., length 22.5 mm, width 8.6 mm. The holotype is not fully mature, and although similar in sculpture and feature of tri-carinate embryonic whorl, differs appreciably in form and shape of whorls (Figs.8,9). There is now very little trace of the colour of "dull brownish-yellow, which is a little deeper on the tubercles" (Watson 1882), and the shell is uniformly creamy-white. Without access to the holotype, the taxon *P.borneensis* Sowerby will remain a *nomen dubium*, since the solitary dorsal view illustration in Sowerby (1859:p.222,fig.22) and very brief description do not assist in a positive interpretation of the species.

Family NASSARIIDAE

Cernohorsky (1986) discussed the specific separation of the two similar species *Nassarius* (*Plicarcularia*) *gibbosulus* (Linnaeus, 1758) and *N.* (*P*) *circumcinctus* (A.Adams, 1852), based on material collected at Kizkalesi, southern Turkey (*leg.* C.Schmidt).

Mrs Schmidt collected additional numbers of both species at Kizkalesi during August 1986, and supplied additional information on the external morphology of the animal and the habitat of the species. *N.* (*P*) *circumcinctus* congregates *c.* 20-25 m from the rocky shore at a depth of *c.* 1.5 m, while *N.* (*P.*) *gibbosulus* lives in colonies 30-40 m from the shore at a depth of 2.0-2.5 m, on a sand substratum at a water temperature of 29°C. In the intervening area occasional specimens of both species may be found.

The animals of the two species are superficially similar but differ in one important diagnostic feature: *N.* (*P.*) *gibbosulus* has 2 metapodial tentacles at the posterior of the foot while *N.* (*P.*) *circumcinctus* has only a single central metapodial tentacle. The radula of a male *N.* (*P.*) *circumcinctus*, shell-length 14.8 mm, has 51 rows of teeth + 9 nascentes. Rachidians are typically nassarine in structure with 11 denticles and the laterals are simple and bicuspid (Fig.10). The radula of a male *N.* (*P.*) *circumcinctus*, shell-length 11.5 mm, with 54 rows of teeth + 8 nascentes, is considerably smaller in relation to shell-length than that of *N.* (*P.*) *gibbosulus*. Rachidians have 10 denticles and laterals, in addition to the two main cusps, also have 2-3 small, central intermediate denticles (Fig.11). It is not known if this feature of intermediate denticles is constant in all populations of *N.* (*P.*) *circumcinctus*.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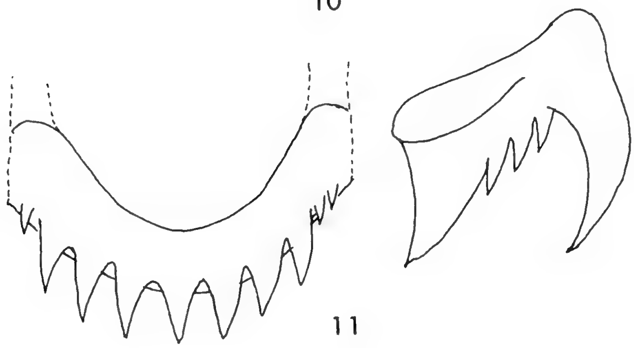
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Figs. 10,11. Half-row of radulae. 10. *Nassarius (Plicarcularia) gibbosulus* (Linnaeus). Male shell-length 14.8 mm. 11. *N.* (*P*) *circumcinctus* (A.Adams). Male shell-length 11.5 mm.

Genus **Nassarius** Dumèril, 1806

Nassarius Dumèril, 1806, Zool.Analytique p.166. Type species by SM (Froriep, 1806) *Buccinum arcularia* Linnaeus, 1758. Recent, Indo-Pacific.

Subgenus **Plicarcularia** Thiele, 1929

Plicarcularia Thiele, 1929, Handb.syst.Weicht. 1:324. Type species by M *Nassa* (*Plicarcularia*) *thersites* (Bruguière) = *Buccinum pullus* Linnaeus, 1758. Recent, Indo-Pacific.

Nassarius (Plicarcularia) oneratus (Deshayes, 1863) (Figs.12,13)

1863. *Nassa onerata* Deshayes, Cat.moll.Ile Reunion p.130,pl.12,figs.24,25.
1984. *Nassarius* (*Plicarcularia*) *oneratus* (Deshayes), Cernohorsky, Bull.Auckland Inst.Mus. No.14:74,pl.6,figs.11-13 (extended synonymy).

TYPE LOCALITY. Reunion I, Indian Ocean.

DISTRIBUTION. From Reunion I to the Marianas and Loyalty Is. Now the Fiji Is.

Specimens of *N.* (*P.*) *oneratus* were recently collected at Susui, N.Lau group, Fiji Is (*leg.* B.Parkinson). This represents an eastward extension from the Loyalty Is.

Subgenus **Zeuxis** H. and A. Adams, 1853

Zeuxis H. & A. Adams, Gen.Rec.Moll. 1:119. Type species by SD (Cossmann, 1901) *Buccinum taenia* Gmelin, 1791 = *B.olivaceum* Bruguière, 1789. Recent, Indo-Pacific.

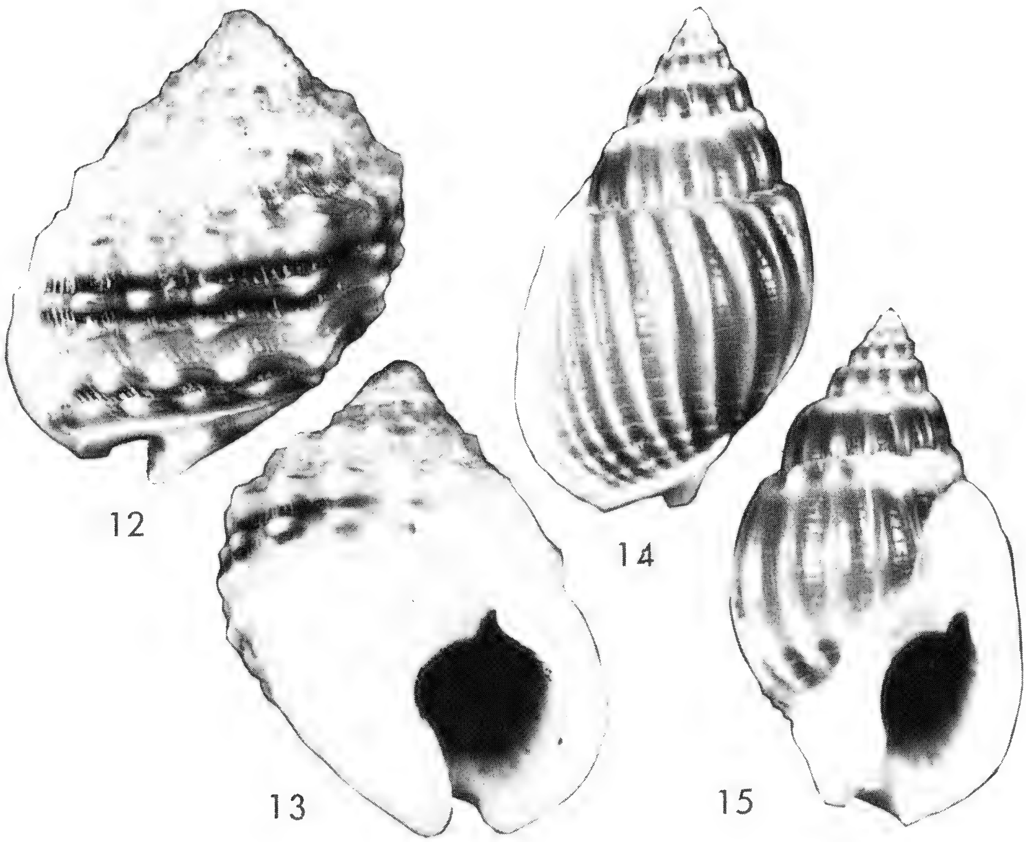
Nassarius (Zeuxis) multicostatus (A.Adams, 1852) (Figs.14,15)

1852. *Nassa multicostata* A.Adams, Proc.Zool.Soc.Lond. Pt.19:98.
1984. *Nassarius* (*Zeuxis*) *multicostatus* (A.Adams), Cernohorsky, Bull.Auckland Inst.Mus. No.14:143, pl.27,figs.9,10; pl.28,fig.1 (extended synonymy).

TYPE LOCALITY. Batangas, Luzon, Philippines, 7 m.

DISTRIBUTION. From Indonesia to the Philippines and the Solomon Is. Now the Fiji Is.

Specimens of *N.* (*Z.*) *multicostatus* were collected at Naselesele, Taveuni I, Fiji Is (*leg.* B.Parkinson). This is an eastward range extension from the Solomon Is.



Figs. 12-15. 12,13. *Nassarius* (*Plicarcularia*) *oneratus* (Deshayes). Susui, Lau group, Fiji Is; 10.8 mm. 14,15. *N.* (*Zeuxis*) *multicostatus* (A.Adams). Naselesele, Taveuni, Fiji Is; 14.2 mm.

Family LITIOPIDAE

1847. Litiopina Gray, Proc.Zool.Soc.Lond. p.155.
1854. Litiopinae H. & A. Adams, Gen.Rec.Moll. 1:324.

Houbrick (1987) in a recent paper on the anatomy of *Alaba* and *Litiopa*, cited the family-group name as Litiopidae Fischer, 1885. However, Gray (1847) and H. & A. Adams (1854) both used the family-group name many years earlier, and the authorship of Litiopidae must be credited to Gray (Art.36a of ICZN).

Family FASCIOLARIIDAE

Genus **Latirus** Montfort, 1810

Latirus Montfort, 1810, Conchyl.Syst. 2:531. Type species by OD *L.aurantiacus* Montfort, 1810 = *Murex gibbulus* Gmelin, 1791. Recent, Indo-Pacific.

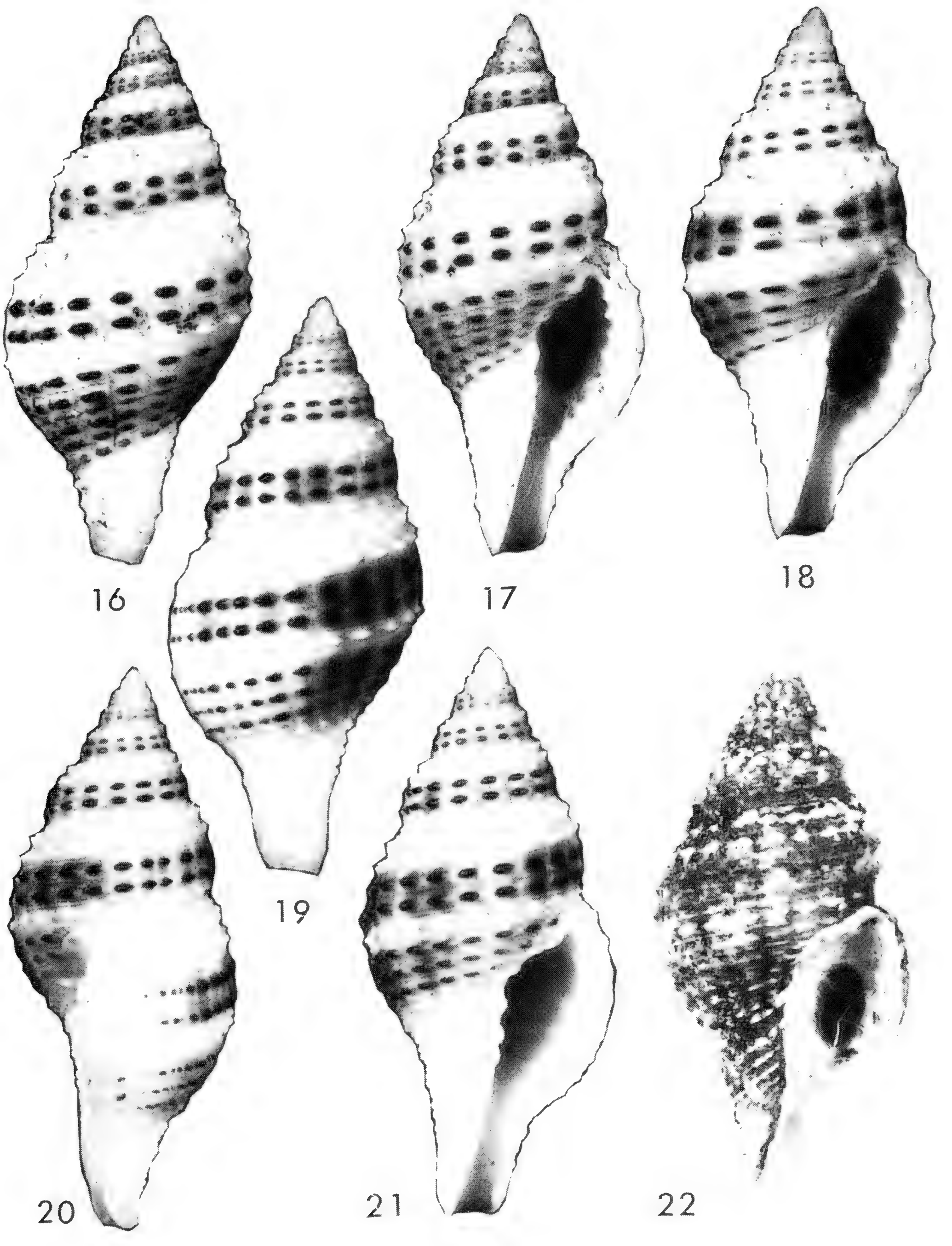
Latirus martinorum sp. n. (Figs.16-24)

Shell moderately small, up to 18.0 mm in length, fusiformly-elongate, width 43-50% of length, solid, protoconch of 2¼-2¾ smooth, glassy-white embryonic whorls which terminate in 4-5 plain arcuate axial ribs before merging into the granulose sculpture of 5¼-6¼ slightly convex whorls of teleoconch. Sculpture granulose, axial sculpture consisting of low axial ribs which number from 15-19 on penultimate and from 12-20 on body whorl; spiral cords override axial ribs and form laterally elongated nodules; penultimate whorl with 5 spiral rows and body whorl with 13-16 rows of nodules, interspaces of nodules with a single fine intermediate spiral thread and numerous, close-set macrostriae. Aperture longer than spire, 54-60% of length, outer lip convex and thickened and with 7-10 strong lirae which continue inside aperture, columella with 3-4 lirae situated centrally, 1-2 on parietal wall and another 1-2 lirae opposite anal canal. Siphonal canal moderately produced, siphonal fasciole with 6-12 close-set, oblique cords. White in colour, spire whorls ornamented with 2 spiral rows of reddish-brown nodules anteriorly, centre of body whorl with 2-3 rows of reddish-brown nodules followed by a single row of white nodules and 4-7 rows of reddish-brown nodules, aperture porcellaneous-white.

Periostracum thin and dirty greyish-brown. Operculum corneous, irregularly ovate and yellowish-brown. Radula minute and with 123 rows of teeth + 10 nascentes. Rachidians small and tricuspid, laterals with 4 large plain cusps and a small inward-facing cusp (Fig.23).

TYPE LOCALITY. Off Coamen I, western Bohol reef, Philippines, in 200-240 m (*leg.* R.Martin, 1986).

Holotype. In the Auckland Institute and Museum No. TM-1373, length 15.6 mm, width 6.9 mm, height of aperture 8.6 mm (Figs.16,17).

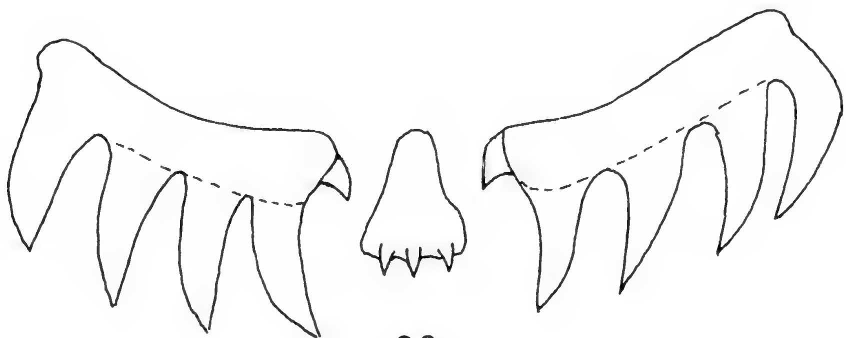


Figs. 16-22. *Latirus martinorum* sp. n. Off Coamen I, Philippines, 200-240 m. 16,17. Holotype AIM No. TM-1373; 15.6 mm. 18. Paratype, 14.2 mm. 19-21. Paratype, 15.9 mm. 22. Paratype with periostracum, 15.8 mm.

Paratypes. Paratypes from the type locality are in the National Museum of Natural History, Smithsonian Institution, Washington, the British Museum (Natural History), London, the Australian Museum, Sydney, coll. R. Martin, Cebu City, Philippines and other collections. A total of 38 specimens have been examined.

There is no known similar species in the Fasciolariidae with which *Latirus martinorum* could be compared. The radula is much closer to species of *Fusinus* than it is to *Latirus*, but since the number of cusps on the lateral teeth is known to vary from 6-11 in *Fusinus*, the same variation can also be expected in *Latirus*. *Fusilatirus pauli* McGinty, 1955, the type species of *Fusilatirus* McGinty, 1955 (= *Dolicholatirus* Bellardi, 1886) from the Florida Keys, has lateral teeth with only 2 cusps.

The species is named for Mr & Mrs R. Martin, Cebu City, Philippines, who discovered this and other new species in the Bohol area.



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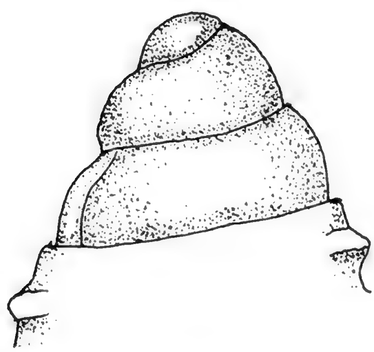

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Figs. 23,24. *Latirus martinorum* sp. n. 23. Full row of radula. 24. Protoconch.

Family MITRIDAE

Genus **Scabricola** Swainson, 1840

Scabricola Swainson, 1840, Treat.Malac. pp.130,131,319. Type species by SD (Gray, 1847) *Mitra serpentina* Lamarck, 1811 = *Voluta variegata* Gmelin, 1791. Recent, Indo-Pacific.

Scabricola vicdani Cernohorsky, 1981 (Fig.25)

1981. *Scabricola vicdani* Cernohorsky, Rec.Auckland Inst.Mus. 18:193,figs.1-3.

TYPE LOCALITY. Punta Engano, Mactan I, Cebu, Philippines.

Previous records of the species were from the Philippines and Papua New Guinea. A specimen of *S.vicdani* has been collected at Viti Levu Bay, N.E. Viti Levu, Fiji Is, in grey mud in 19 m (*leg*. B.Parkinson). This record is an eastward range extension for the species.

Family COSTELLARIIDAE

Genus **Vexillum** Röding, 1798

Vexillum Röding, 1798, Mus.Bolten. p.138. Type species by SD (Woodring, 1928) *V.plicatum* Röding, 1798 = *Voluta plicaria* Linnaeus, 1758. Recent Indo-Pacific.

Subgenus **Costellaria** Swainson, 1840

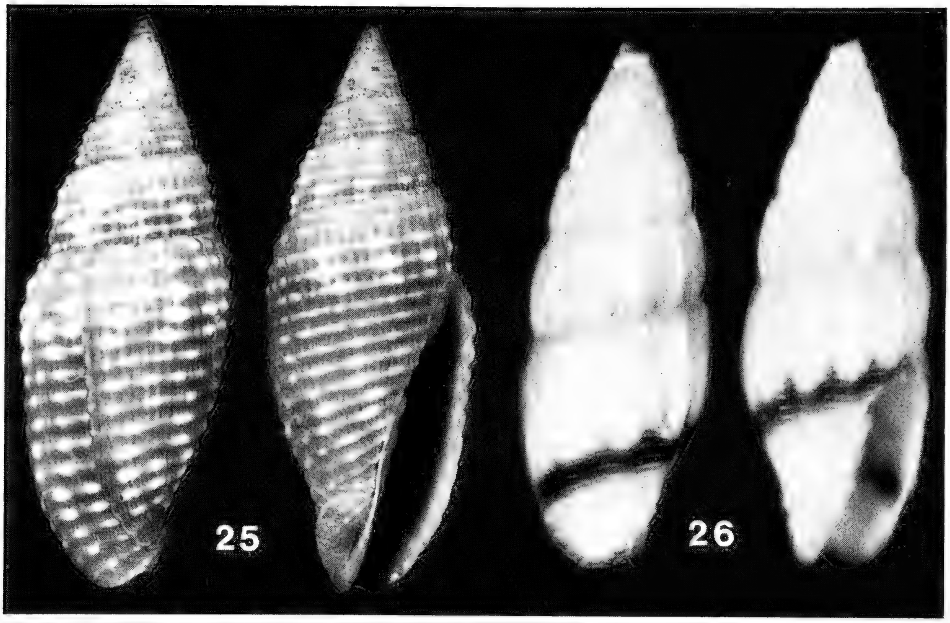
Costellaria Swainson, 1840, Treat.Malac. pp.130.320. Type species by M *Mitra rigida* Swainson, 1821 = *Mitra semifasciata* Lamarck, 1811. Recent, Indo-Pacific.

Vexillum (Costellaria) verecundulum (Hervier, 1897) (Fig.26)

1897. *Mitra (Costellaria) verecundula* Hervier, J.Conchyl. 45(1):68; 1899 Hervier, J.Conchyl. 46(3):212, p.10,fig.5; 1923 Dautzenberg & Bounge, J.Conchyl. 67(2):219.
1950. *Mitra verecundula* Hervier, Fischer-Piette, J.Conchyl. 90(3):164.
1981. *Vexillum (Costellaria) verecundula* (Hervier), Cernohorsky, Bull.Mus.Nat.Hist.Nat. Paris (4), 3(A-No.1):98, pl.2,figs.9,10.

TYPE LOCALITY. Lifu, Loyalty Is.

In a paper on Hervier's type specimens of Mitridae and Costellariidae (Cernohorsky 1981) I considered the taxon *V. (C.) verecundulum* Hervier, 1897, a *species inquirenda*. The 3 syntypes examined, length 7.2 — 9.1 mm, were all very worn and in the absence of live taken examples the species could not be elucidated. The recent collection of a living 6.9 mm specimen at Naselesele, Taveuni I, Fiji Is (*leg*. B.Parkinson) enables me to confirm the validity of the taxon *V. (C.) verecundulum*.



Figs 25.26. *Scabricola vicdani* Cernohorsky. Viti Levu Bay, Fiji Is, 19 m; 28.6 mm. 26. *Vexillum* (*Costellaria*) *verecundulum* (Hervier). Naselesele, Taveuni, Fiji Is; 6.9 mm.

The species is small in size, fusiformly-elongate, with 6½ regularly convex whorls and a missing protoconch. Axial ribs number 11 on the penultimate whorl and 8 on the body whorl, spiral grooves are distinct and number 7-8 on the penultimate and 21 on the body whorl. Aperture is shorter than the spire, lirate within, columella with 4 folds. White in colour, with a single brown peripheral band which tends to elongate into spots on the body whorl.

Family TEREBRIDAE

Genus **Terebra** Bruguière, 1789

Terebra Bruguière, 1789, Encycl.Méth.Vers (1) p.XV. Type species by SD (Lamarck, 1799) *Buccinum subulatum* Linnaeus, 1767. Recent, Indo-Pacific.

Terebra bratcherae sp. n. (Figs.27-30)

Shell small, 9.7 — 14.1 mm in length, width 20-25% of length, teleoconch of 8-10¼ weakly convex to almost flat-sided whorls, protoconch with 1½ large, bulbous and glassy smooth embryonic whorls, sutures distinctly incised. Upper spire whorls with a moderately crisp sculpture of arcuate axials and 6-7 spiral threads; axials extend from suture to suture, anteriorly bisected by a spiral groove. Both axial and spiral sculpture becoming obsolete on last two whorls, axial ribs slender, irregular and arcuate, numbering 26-31 on penultimate and from 23-35 on body whorl; obsolete spiral striae number from 4-6 on penultimate whorl. Axial ribs on body whorl fade out at

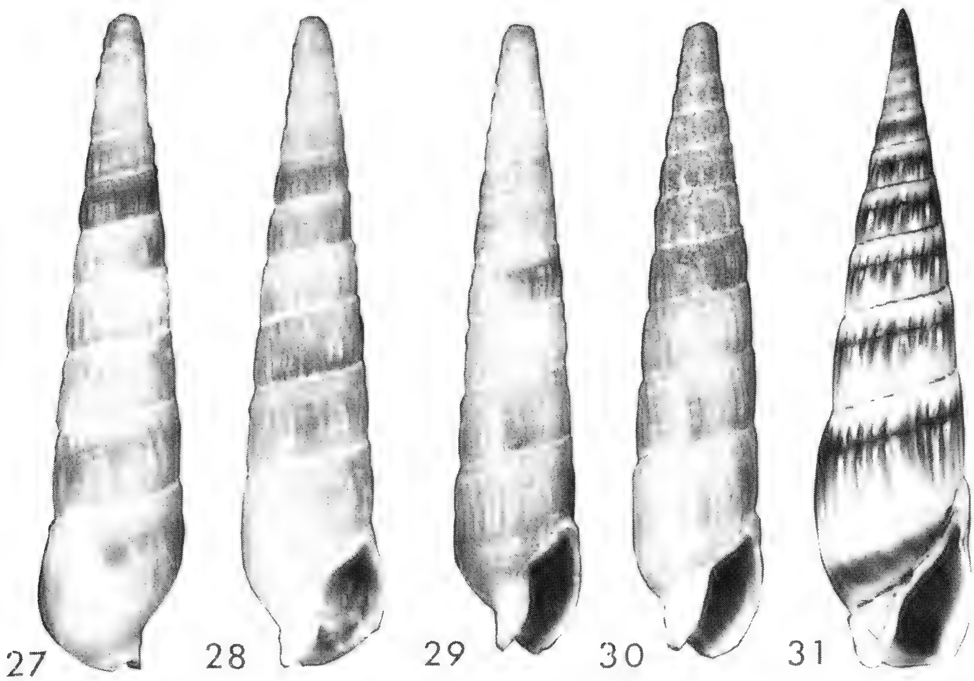
periphery, lower half of body whorl with 6-7 close-set spiral striae. Aperture small, columella calloused and with a weak basal fold anteriorly. Cream in colour, ornamented with nebulous orange-brown axial streaks. Operculum elongate-ovate, thin and corneous, pale yellowish-brown in colour.

TYPE LOCALITY. St.37, N.W. of Rottnest I, West Australia, 31°44′S & 115°03′E, 183-192 m (*leg.* H.M.A.S. "Diamantina", 18-3-1972).

Holotype. In the Australian Museum, Sydney, No. C-149460, length 14.1 mm, width 3.2 mm (Figs.27,28).

Paratypes. Four paratypes from the type locality in the Australian Museum, Sydney. One paratype, length 9.7 mm, width 2.4 mm from St.74, N. of Lancelin, West Australia, 31° 16′S & 114° 54′E, 274 m, fine mud (*leg.* H.M.A.S. "Diamantina", 23-3-1972) in the Western Australian Museum, Perth, No. 365-86.

This small species is not really similar to any other described Indo-Pacific species. It superficially resembles *T.fuscotaeniata* Thiele, 1925, from Sumatra, Indonesia, which is similar in size and also has a paucispiral protoconch, but *T.fuscotaeniata* has more numerous, convex whorls, more distinct axial ribs and spiral striae and no subsutural groove. Another superficially similar species is *T.tiurensis* Schepman, 1913,



Figs. 27-31. 27-30. *Terebra bratcherae* sp. n. N.W. of Rottnest I, W.Australia, 183-192 m. 27,28. Holotype AMS No. C-149460; 14.1 mm. 29. Paratype, 13.4 mm. 30. Paratype, 13.7 mm. 31. *Hastula (Impages) anomala* (Gray). Vatukarasa, Fiji Is; 36.5 mm.

from Timor, Indonesia, which is similar in size with similar whorls, but *T.tiurensis* is punctate on the subsutural band, the protoconch is conical and violet in colour and spiral sculpture is absent.

This species is named for Mrs Twila Bratcher, Museum Associate of the Los Angeles County Museum of Natural History, in recognition of her research and publication on the family Terebridae, and who has, in many ways, assisted my own studies of Indo-Pacific Mollusca.

Genus **Hastula** H. and A. Adams, 1853

Hastula H. & A. Adams, 1853, Gen.Rec.Moll. 1:225. Type species by SD (Cossmann, 1896) *Terebra strigillata* Lamarck = *Buccinum strigilatum* Linnaeus, 1758. Recent, Indo-Pacific.

Subgenus **Impages** E.A. Smith, 1873

Impages E.A. Smith, 1873, Ann.Mag.Nat.Hist. (4), 11(64):263. Type species by SD (Cossmann, 1896) *Terebra caerulescens* Lamarck, 1822 = *Buccinum hecticum* Linnaeus, 1758. Recent, Indo-Pacific.

Hastula (Impages) anomala (Gray, 1834) (Fig.31)

1834. *Terebra anomala* Gray, Proc.Zool.Soc.Lond. Pt.2:62; 1844 Hinds in Sowerby, Thes.Conchyl. 1:180, pl.44,fig.97; 1917 Hirase, Terebridae Jap.Emp. p.33,pl.2,figs.6,7.
1961. *Noditerebra* (*Diplomeriza?*) *anomala* (Gray), Oyama, Venus: Jap.J.Malac. 21(2):182.
1961. *Impages* (?) *anomala* (Gray), Oyama & Takemura, Mollusc.shells Res.Expl.Inst. 5:pl.47,figs.12,13.
1987. *Hastula* (*Impages*) *anomala* (Gray), Bratcher & Cernohorsky, Living Terebras world p.190,pl.58,figs.229a-c; col.pl.D,fig.7.

TYPE LOCALITY. Singapore, Malaysia (designated Bratcher & Cernohorsky 1987).

The species has been previously reported to live in the area extending from Madagascar to the Philippines and Japan. Specimens have been collected at Vatukarasa, S.coast of Viti Levu, Fiji, in black volcanic sand, in 6 m (*leg.* B.Parkinson). This is a major eastward range extension.

Family TURRIDAE

Genus **Lophiotoma** Casey, 1904

Lophiotoma Casey, Trans.Acad.Sci.St.Louis 14(5):130. Type species by SD (Woodring, 1928) *Pleurotoma tigrina* Lamarck, 1822 = *P.acuta* Perry, 1811. Recent, Indo-Pacific.

Subgenus **Xenuroturris** Iredale, 1929

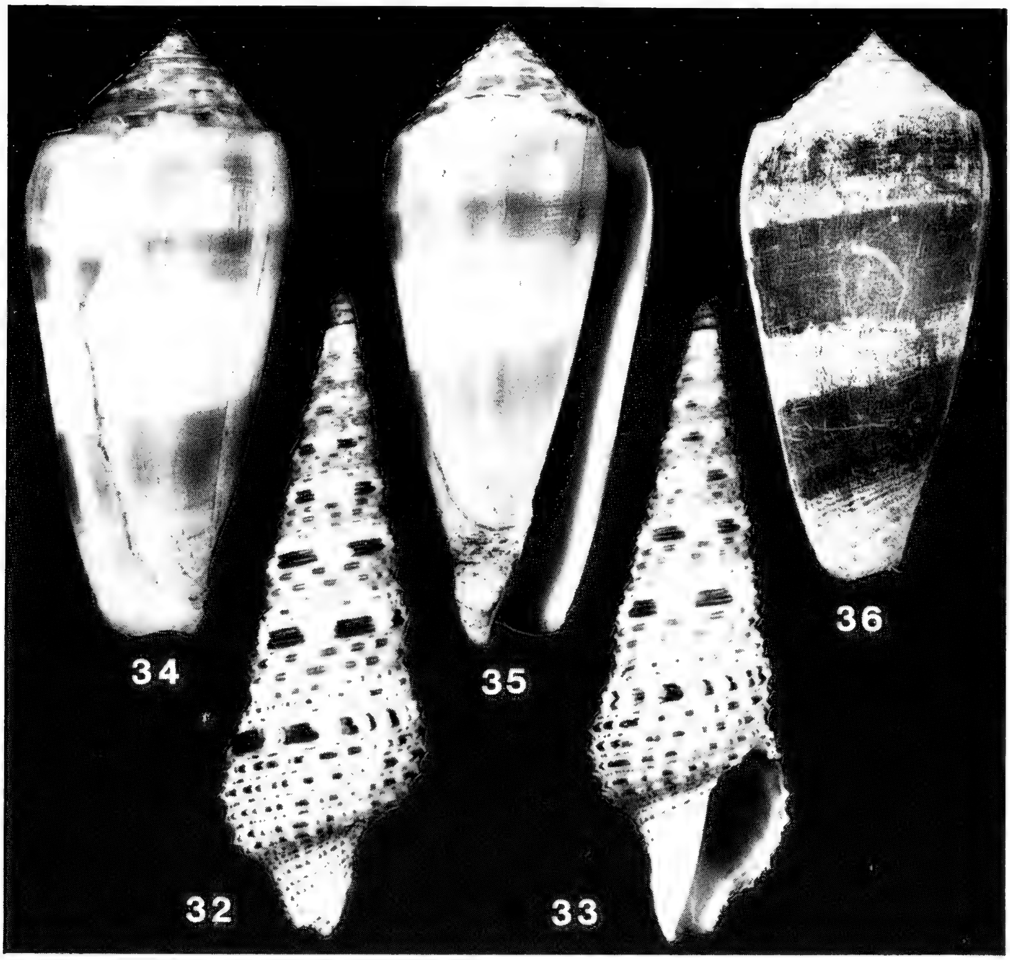
Xenuroturris Iredale, 1929, Mem.Queensl.Mus. 9(3):285. type species by OD *X.legitima* Iredale, 1929 = *Pleurotoma cingulifera* Lamarck, 1822. Recent, Indo-Pacific.

Lophiotoma (Xenuroturris) kingae (Powell, 1964) (Fig.32,33)

1964. *Xenuroturris kingae* Powell, Indo-Pacific Moll. 1(5):325, pl.252.fig.6; 1979 Kay, Hawaiian mar.shells p.342,figs. 111F, 1130,P; 1980 Cernohorsky, Rec.Auckland Inst.Mus. 16:184,fig.31.

TYPE LOCALITY. Off Keehi, Oahu, Hawaiian Is, 20-40 fathoms (36-73 m).

The species was originally described from the Hawaiian Is, and a westward range extension to Guam, Marianas Is, was later reported (Cernohorsky 1980). A specimen has recently been collected at Cuvu Harbour, W.Viti Levu, Fiji Is, in white sand, in 27 m (*leg.* B.Parkinson). This record represents a considerable range extension south of the equator.



Figs. 32-36. 32,33 *Lophiotoma* (*Xenuroturris*) *kingae* (Powell). Cuvu Harbour, Fiji Is, 27 m; 27.6 mm. 34-36. *Conus consors* Sowerby. 34,35. Nukulau I, Fiji Is, 25 m; 67.4 mm. 36. Natewa Bay, Fiji Is, 25 m. Specimen with periostracum; 55.2 mm.

Family CONIDAE

Genus **Conus** Linnaneus, 1758

Conus Linnaeus, Syst.Nat.ed.10:712. Type species by SD (Children, 1823) *C.marmoreus* Linnaeus, 1758. Recent, Indo-Pacific.

Conus consors Sowerby, 1833 (Figs.34-36)

1833. *Conus consors* Sowerby, Conch.Illust. Pt.36:fig.42; 1843 Reeve, Conch.Icon.1:pl.21, fig.121; 1858 Sowerby, Thes.Conchyl. 3(18):36, pl.20,fig.492; 1979 Walls, Cone shells p.366, illust.on p.241 (see for synonymy); 1985 Coomans,Moolenbeek & Wils, Basteria 48:257, figs.87,441,519-521.

TYPE LOCALITY. Singapore, Malaysia (designated by Coomans, Moolenbeek & Wils 1985).

Walls (1979) reported the species from as far east as the Solomon Is and Coomans, Moolenbeek & Wils (1985) from New Caledonia. Several specimens of *C.consors* have been collected by Mr B. Parkinson and his team of divers at Nukulau I, Fiji, in soft brown mud, at 25 m depth, and at Natewa Bay, Fiji, in black volcanic soil, in 25 m.

It has been suggested that *C.consors* is synonymous with *C.magus* Linnaeus. Apart from distinct morphological differences between the two species, *C.magus* is a common intertidal species in the Fiji Is whereas *C.consors* is rare and occurs only subtidally. No intergrades between the two species have been encountered.

Acknowledgements. For the loan of specimens of *Terebra bratcherae* I am grateful to Dr W. Ponder and Mr I. Loch, Australian Museum, Sydney, and Dr F. Wells, Western Australian Museum, Perth. I would like to thank Mr V. Dan, Manila, Philippines, Mr R. Martin, Cebu City, Philippines, Mr B. Parkinson, formerly of Suva, Fiji Is, and Mrs C. Schmidt, Feldkirchen, Austria, for molluscan material and pertinent information.

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TAXONOMIC NOTES ON SOME DEEP-WATER TURRIDAE (MOLLUSCA: GASTROPODA) FROM THE MALAGASY REPUBLIC

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Abstract. The ten Turridae species treated in this paper are mostly new geographical or benthic records. The identity of *Gemmula congener* (E.A. Smith) is here elucidated on the basis of its type specimen, and *G.cosmoi* (Sykes) is considered a separate species rather than a subspecies of *G.congener*. The status of the holotype of *G.philippinensis* (Powell) is discussed and *Comitas huttoni* (Suter,1914) is the appropriate name for the species known as *Comitas fusiformis* (Hutton, 1877).

The taxonomic notes on the ten species of Turridae discussed in this paper have been based on material dredged by Prof. A. Crosnier, in deep water off "Madagascar" (= Malagasy Republic), during the years 1972-73. The material is normally housed in the Delaware Museum of Natural History, Greenville, Delaware, but has been on an extended loan to the Auckland Institute and Museum.

Family TURRIDAE

Subfamily TURRINAE Swainson, 1840

Genus **Gemmula** Weinkauff, 1875

Gemmula Weinkauff, 1875, Jahrb.deut.Malak.Gesell. 2:287. Type species by SD (Cossmann, 1896) *Pleurotoma gemmata* Reeve, 1843 (non Conrad, 1835) = *Gemmula hindsiana* Berry, 1958. Recent, California.

Gemmula (Gemmula) congener (E.A. Smith, 1894) (Figs.1-5)

1894. *Pleurotoma congener* E.A. Smith, Ann.Mag.Nat.Hist. (6), 14:160, pl.3, figs.4,5.
1964. *Gemmula congener* subsp. *congener* (E.A. Smith), Powell, Indo-Pacif.Moll. 1(5):251, pl.191, figs.1-4.
1971.? *Gemmula* (*Gemmula*) *rarimaculata* Kuroda & Oyama, Seashells Sagami Bay, p.222, pl.57, fig.9; pl.111, fig.6; 1983 Kilburn, Ann.Natal Mus. 5(2):577, figs.9,17,50-52.

TYPE LOCALITY. Bay of Bengal, India. 128 fathoms (234 m) [*congener*]; Sagami Bay, Japan (*rarimaculata*).

Rec. Auckland Inst. Mus. 24: 123-134 18 December 1987

Type specimen. The holotype of *G.congener* is in the Zoological Survey of India No.8513/9, length 51.4 mm, width 18.0 mm, height of aperture 23.3 mm. There are 45 gemmae on the penultimate and 48 on the body whorl (some being almost confluent towards the end of the body whorl). The shell is uniformly creamy-fawn and unspotted; the outer lip and sinus are damaged (Figs.2,3).

Material examined: Malagasy: 22°21′06″S & 43°04′03″E, 450 m; 15°19′01″S & 46°11′08″E, 400 m. Total 7 specimens.

Powell (1964) assigned 3 living and 1 fossil subspecies to the *congener* group. *Gemmula congener* is here considered to be a separate species from *G.cosmoi* (Sykes), which also occurs in Malagasy. Powell (1964) reported *G.congener* only from the northern Indian Ocean, ranging from Somalia to the Persian Gulf, India and the Philippines. In addition to the new Malagasy record, the species was also collected N.W. of Zanzibar by the John Murray Expedition in 1933-34.

Kilburn (1983) did not consider Powell's (1964) illustration of *G.congener* to be accurate and he remarked that Powell's (1964) illustration of *G.congener* was more comparable to *G.rarimaculata* Kuroda & Oyama, 1971. Having examined the holotype of *G.congener* and 20 additional specimens of the species, I consider Powell's (1964) interpretation of the species to be correct. The misunderstanding seems to be the variability of the development of the bicarinate subsutural cord. Some specimens have the subsutural cord almost of the same strength as the gemmate peripheral cord on the upper spire whorls but on the last two whorls the subsutural cord becomes lower and more discreet. In other specimens the subsutural cord is prominent to massive on all whorls; the cord can be either plain or have the appearance of being ribbed in individuals where the oblique axials intrude on to the subsutural cord. From the original description and illustration of *G.rarimaculata* and subsequent illustration of the species by Kilburn (1983), the species appears to be conspecific with *G.congener* (E.A. Smith).

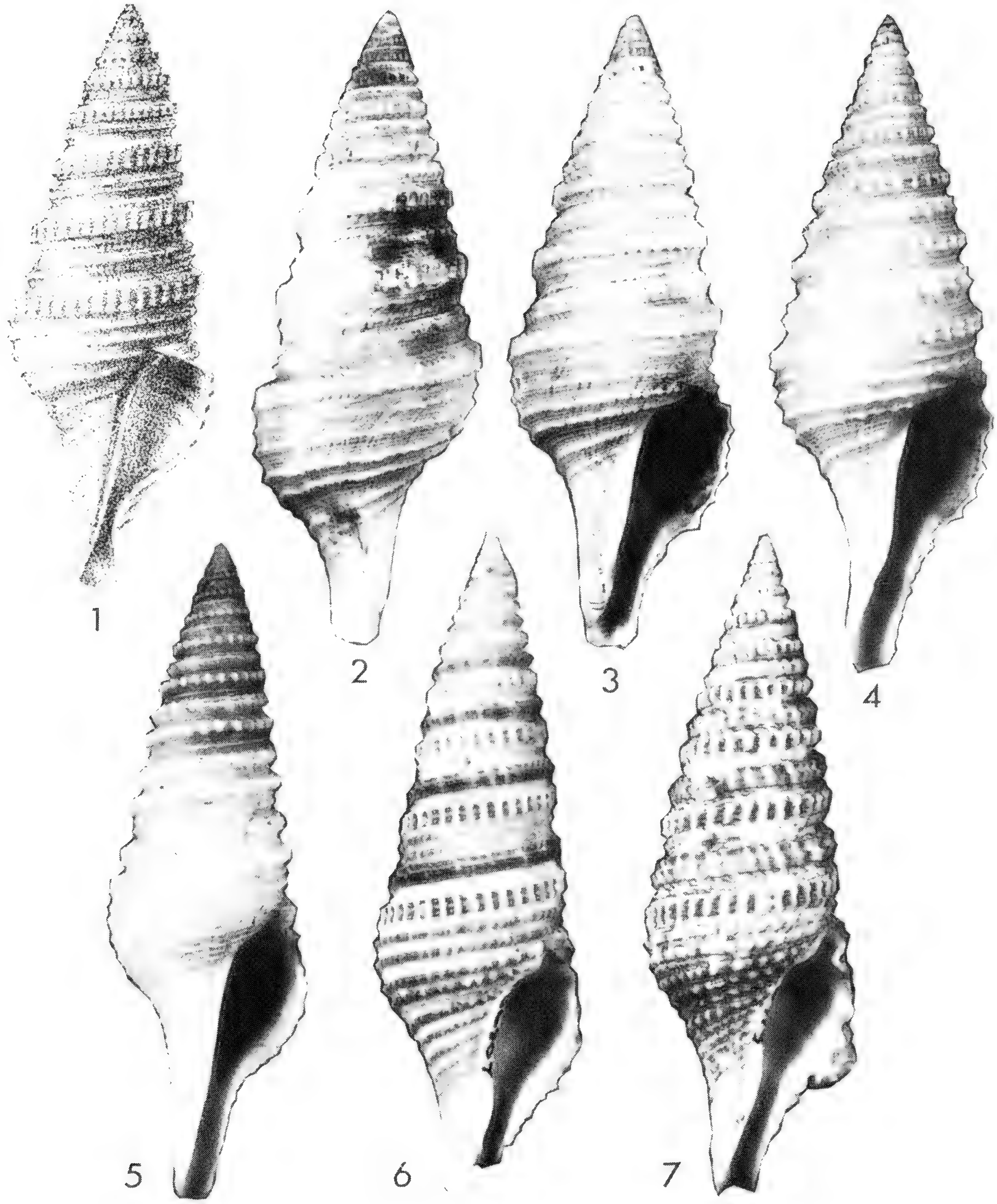
Gemmula (Gemmula) webberae Kilburn, 1975 (Figs.6,7)

1975. *Gemmula congener* subsp. *webberae* Kilburn, Ann.Natal Mus. 22(2):600, figs 13,14.
1983. *Gemmula (Gemmula) webberae* Kilburn, Ann.Natal Mus. 25(2):569.

TYPE LOCALITY. Off Durban, Natal, Sth. Africa, in *c.* 150 fathoms (275 m).

Material examined: Malagasy: 12°43′03″S & 48°15′07″E, 245-255 m. A single specimen, length 57.9 mm.

The species is similar to *G.congener* (E.A. Smith) but is always readily separated. In addition to the new Malagasy record, I have seen other specimens from N.W. of Zanzibar where it has been collected by the John Murray Expedition. In these specimens, the strength of the subsutural cord was as variable as in *G.congener*.



Figs. 1-7. 1-5. *Gemmula congener* (E.A. Smith). 1. Type figure (from E.A. Smith 1894, pl.3,Figs.4,5). 2,3. Holotype in Zool. Surv.India No. 8513/9; 51.4 mm. 4. Andaman Sea, 339 m, ex-"Investigator"; 38.4 mm (specimen with fewer gemmae on cords). 5. Malagasy, 450 m; 36.3 mm (slender form). 6,7. *G.webberae* Kilburn. 6. Malagasy, 245-255 m; 57.9 mm. 7. Off N.W. Zanzibar, 212 m; 50.7 mm.

Gemmula (Gemmula) cosmoi (Sykes, 1930) (Fig.8)

1930. *Turris cosmoi* Sykes, Proc.Malac.Soc.Lond. 19:82, textfig.
1964. *Gemmula congener* subsp. *cosmoi* (Sykes), Powell, Indo-Pacif.Moll. 1(5):252, pl.192.
1983. *Gemmula (Gemmula) cosmoi* (Sykes), Kilburn, Ann.Natal Mus. 25(2):567, figs.8,14,33-36.

TYPE LOCALITY. Kii, Japan.

Material examined: Malagasy: 12°17′03″S & 43°02′07″E, 600-605 m; 12°39′08″S & 48°15′02″E, 375-385 m; 22°14′08″S & 43°04′07″E 450 m; 15°18′S & 46°12′01″E, 480-510 m; 22°17′09″S & 43°04′E, 450 m; 12°43′01″S & 48°11′01″E, 540 m; 23°36′04″S & 43°31′01″E, 450-460 m; 22°21′06″S & 43°04′03″E, 450 m; 22°14′07″S & 43°04′05″E, 470-475 m; 15°19′S & 46°11′08″E, 405 m; 15°19′01″S & 46°11′08″E, 400m; 15°24′05″S & 46°02′E, 250-265 m; 23°36′01″S & 43°31′E, 445 m. Total 54 specimens.

Powell (1964) considered *G.cosmoi* to be a subspecies of *G.congener*, however, Kilburn (1983) subsequently separated *G.cosmoi* from *G.congener*. This separation is confirmed by the occurrence of both species in Malagasy and absence of any intergrading individuals. *G.cosmoi* is more closely related to *G.speciosa* (Reeve) than it is to *G.congener*.

Powell (1964) considered *G.cosmoi* to be endemic to Japan, but Kilburn (1983) subsequently reported the species from Natal and southern Mozambique. This range is now extended to Malagasy where the species is moderately common in dredgings.

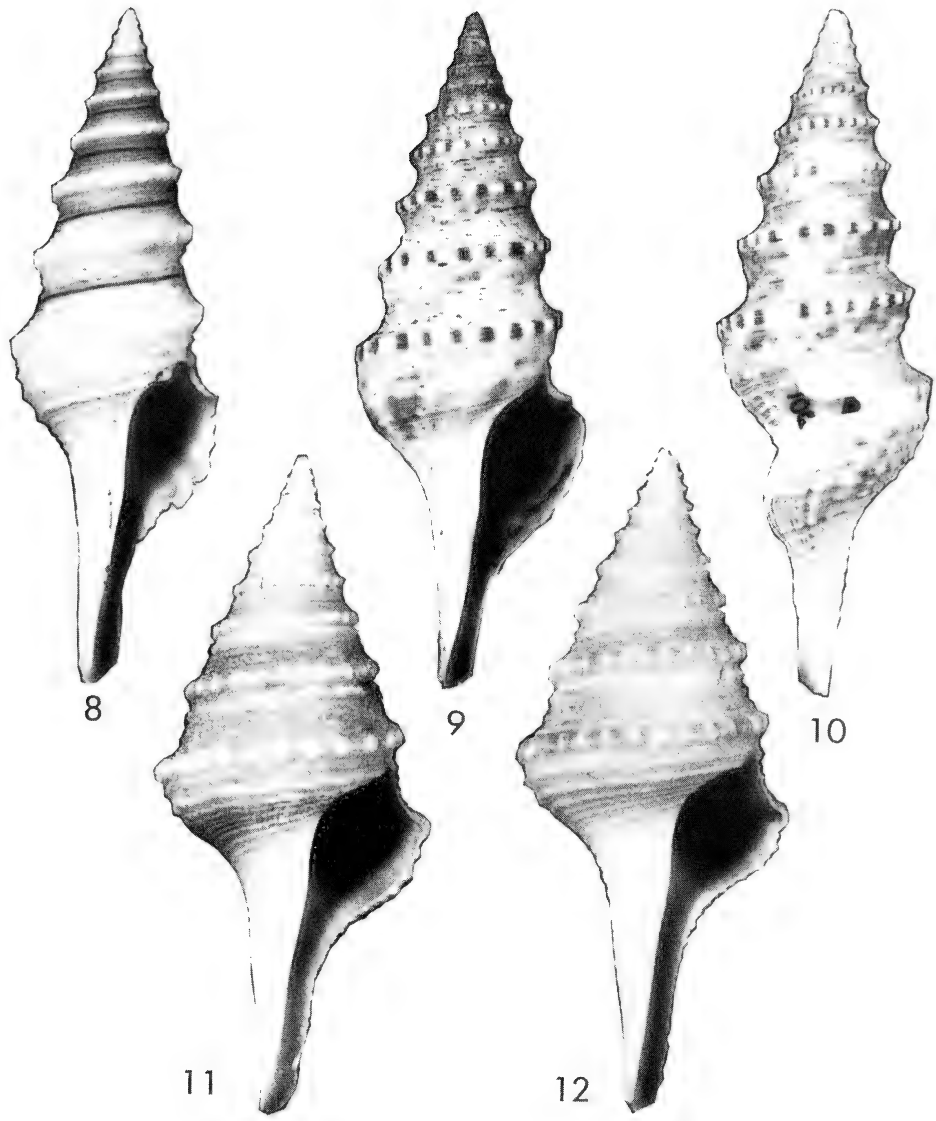
Gemmula (Gemmula) kieneri (Doumet, 1840) (Figs.9,10)

1840. *Pleurotoma kieneri* Doumet, Magasin de Zool. 2:2, pl.10.
1843. *Pleurotoma carinata* Reeve, Conch.Icon. 1:pl.7, fig.56 (non Link,1808; nec Gray in Griffith & Pidgeon,1834).
1964. *Gemmula kieneri* (Doumet), Powell, Indo-Pacific.Moll. 1(5): 246, pl.186, figs.2,3.
1983. *Gemmula (Gemmula) kieneri* (Doumet), Kilburn, Ann.Natal Mus. 25(2):569, figs.7,13,37,38,40.

TYPE LOCALITY. None.

Material examined: Malagasy: 15°14′05″S & 46°11′08″E, 405 m; 15°19′01″S & 46°11′08″E, 400 m; 12°27′S & 48°08′05″E, 695-705m; 23°36′01″S & 43°31′E, 445 m; 12°46′05″S & 48°10′04″E, 495-500m; 12°42′04″S & 48°14′03″E, 285-295 m; 12°43′S & 48°15′E, 300-340 m; 22°14′08″S & 43°04′07″E, 450 m; 12°49′02″S & 48°12′01″E, 445-455 m; 15°20′05″S & 46°09′E, 310-350 m; 18°54′S & 43°55′E, 280-310 m; 12°39′08″S & 48°15′02″E, 375-385 m; 21°25′05″S & 43°14′05″E, 425-550 m; 12°43′01″S & 48°11′01″E, 540 m; 23°36′04″S & 43°31′01″E, 450-460 m; 22°17′09″S & 43°04′E, 450 m; 22°17′03″S & 43°02′07″E, 600-605 m; 12°52′04″S & 48°10′04″E, 400-410 m; 22°14′07″S & 43°04′05″E, 470-475 m; 12°41′03″S & 48°16′E, 308-314 m. Total 95 specimens; largest 60.0 mm in length.

This is one of the commonest turrid species in Malagasy dredgings.



Figs. 8-12. 8. *Gemmula cosmoi* (Sykes). Malagasy, 450 m; 48.3 mm. 9,10. *G.kieneri* (Doumet). 9. Malagasy, 445 m; 57.0 mm. 10. Malagasy, 600-605 m; 60.4 mm. 11,12. *G.aethiopica* (Thiele). 11. Malagasy, 550-555 m; 32.4 mm. 12. Malagasy, 405 m; 38.0 mm.

Gemmula (Gemmula) aethiopica (Thiele, 1925) (Figs.11,12)

1925. *Pleurotoma (Gemmula) aethiopica* Thiele, Wiss.Ergeb.deut.Tief.Exped. "Valdivia" 17(2):174, pl.22, fig.25.
1964. *Gemmula aethiopica* (Thiele), Powell, Indo-Pacif.Moll. 1(5):257, pl.196, fig.5.

TYPE LOCALITY. Off Somalia, E.Africa, 0°27.4′S & 42°47.3′E, 638 m.

Material examined: Malagasy: 22°17′03″S & 43°02′07″E, 600-605 m; 23°34′S & 43°29′06″E, 600-610 m; 23°35′05″S & 43°28′06″E, 710-760 m; 12°42′02″S & 48°14′02″E, 395-405 m; 15°19′S & 46°11′08″E, 405 m; 22°25′S & 43°04′05″E, 550-555 m; 18°54′S & 43°55′, 280-310 m. Total 20 specimens.

Thiele (1925) counted 32 nodules on the peripheral cord of the body whorl. The number of nodules in specimens examined varied from 22-36 and the number of spiral threads was also found to be variable.

Subgenus **Pinguigemmula** MacNeil, 1960

Pinguigemmula MacNeil, 1960, U.S.Geol.Surv.Prof.Pap. 339:103. Type species by OD *P.okinavensis* MacNeil, 1960. Recent, Indo-Pacific.

Gemmula (Pinguigemmula) philippinensis (Powell, 1964) (Figs.13,14)

1964. *Pinguigemmula philippinensis* Powell, Indo-Pacific.Moll. 1(5):278, pl.215, figs.5,6.

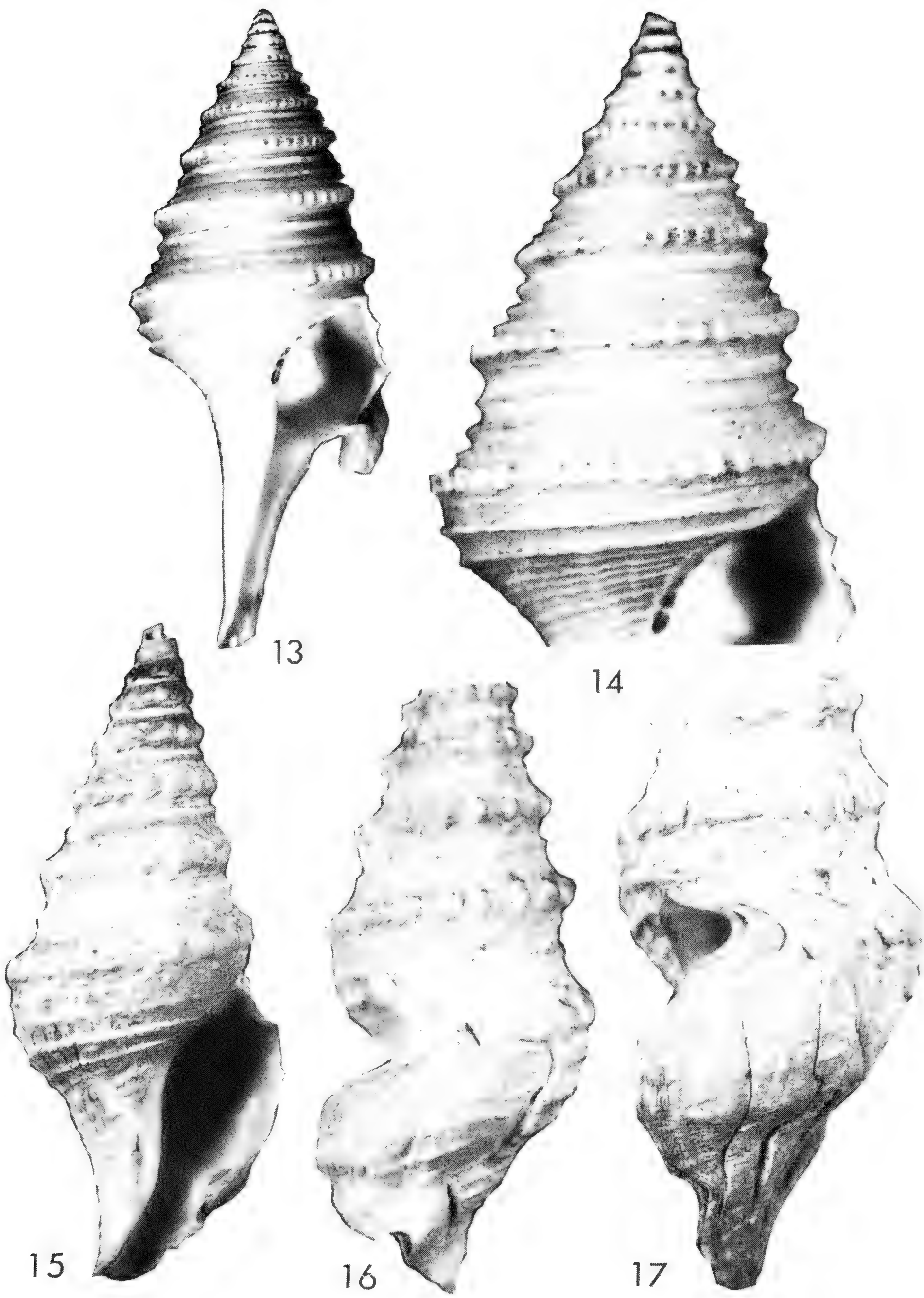
TYPE LOCALITY. Off Santiago, W.Luzon, Philippines, 280 fathoms (512 m).

The opportunity is taken to correct an error made by Powell (1964, 1966) in illustrating the holotype of *G.philippinensis.* In 1964 (pl.215, figs.5,6) Powell illustrated a specimen with a malformed sinus growth as the "holotype" of *G.philippinensis*, and gave the measurements as 50.2mm. In 1966 (pl.6, fig.5), Powell once again illustrated the same specimen as the holotype. The holotype, however, is in the National Museum of Natural History, Washington, length 50.2 mm, and has been correctly illustrated by Abbott & Dance (1982). The specimen illustrated by Powell on both occasions (1964, 1966) is a paratype which is in the Powell collection and measures length 43.5 mm (Figs.13,14).

Kilburn (1971) synonymized *G.philippinensis* (Powell) with *G.thielei* (Finlay, 1930) from East Africa.

Subgenus **Ptychosyrinx** Thiele, 1925

Ptychosyrinx Thiele, 1925, Wiss.Ergeb.deut.Tief.Exped."Valdivia" 17(2):210. Type species by OD *Pleurotoma (Subulata) bisinuata* v.Martens, 1901. Recent, East Africa.



Figs. 13-17. 13,14. *Gemmula* (*Pinguigemmula*) *philippinensis* (Powell). Paratype from off Santiago, W.Luzon, Philippines, 512 m; 43.5 mm. 15-17. *Gemmula* (*Ptychosyrinx*) *bisinuata* (v.Martens). 15. Malagasy, 1,200 m; 45.8 mm. 16. Side-view of younger specimen; 38.7 mm. 17. Side-view of senile specimen; 45.8 mm.

Gemmula (Ptychosyrinx) bisinuata (v.Martens, 1901) (Figs.15-17)

1901. *Pleurotoma (Subulata) bisinuata* v.Martens, Sitzb.Gesell. Nat.Freunde Berlin p.17.
1903. *Drillia (Subulata) bisinuata* v.Martens, Wiss.Ergeb.deut.Tief.Exped. "Valdivia" 7:82, pl.1, fig.8.
1964. *Ptychosyrinx bisinuata* (Martens), Powell, Indo-Pacific.Moll. 1(5):289, pl.223, figs.1,2.

TYPE LOCALITY. St.264, near the coast of Somalia, 6° 18′N & 49° 32′E, in 1079 m, Globigerina-mud.

Material examined: Malagasy: 22° 20′03″S & 42° 59′E, 995-1020 m; 22° 16′09″S & 42° 56′E, 1200 m; 22° 18′02″S & 43° 00′05″E, 880-920 m. Total 9 specimens.

Powell (1964) considered the bisinuate nature of the outer lip to be an abnormality. However Malagasy specimens with an entire aperture clearly show the feature of a bisinuate outer lip. An outer lip with a double sinus occurs occasionally in other species of *Gemmula*, such as *G.graeffei* (Weinkauff), or the illustrated examples of *G.webberae* Kilburn (Fig.6,7) and *G.philippinensis* (Powell) [Fig.13,14]. The double sinus does appear to occur more frequently in *G.bisinuata* than other *Gemmula* species.

Subfamily COCHLESPIRINAE Powell, 1942

[formerly TURRICULINAE Powell, 1942]

Genus **Comitas** Finlay, 1926

Comitas Finlay, 1926, Trans.N.Z.Inst. 56:251. Type species by OD *Surcula huttoni* Suter, 1914. Tertiary of New Zealand.

Powell (1969) used the name *Comitas fusiformis* (Hutton, 1877) for *Surcula huttoni* Suter. Since Hutton's "*Drillia fusiformis*" has been replaced as a secondary homonym prior to 1961, the taxon remains permanently rejected (Art.59 of ICZN 1985).

Comitas kaderlyi (Lischke, 1872) (Fig.18)

1872. *Pleurotoma kaderlyi* Lischke, Malakozool. Blaetter 19:100.
1969. *Comitas kaderlyi* (Lischke), Powell, Indo-Pacif.Moll. 2(10):265, col.pl.192, figs.12-14; pl.216, fig.3.

TYPE LOCALITY: Bay of Yedo, Japan.

Material examined: Malagasy: 15° 19′S & 46° 11′08″E, 405 m; 22° 17′03″S & 43° 02′07″E, 600-605 m; 15° 18′S & 46° 12′01″E, 480-510 m; 22° 17′09″S & 43° 04′E, 450 m; 18° 54′S & 43° 55′E, 280-310 m; 22° 14′08″S & 43° 04′07″E, 450 m. Total 9 specimens.

Powell (1969) reports the species from the Philippine-Japanese region and the Malagasy record is a considerable westward range extension into the Indian Ocean. The largest specimen examined measured 80.4 mm in length.

Comitas eurina (E.A. Smith, 1899) (Figs.19,20)

1899. *Pleurotoma (Surcula) eurina* E.A. Smith, Ann.Mag.Nat.Hist. (7), 4:239; 1909 Annandale & Stewart, Illust.Zool. "Investigator", Moll. Pt.6:pl.9, figs.4,4a.
1969. *Comitas eurina* (E.A. Smith), Powell, Indo-Pacific.Moll. 2(10):268, pl.217, figs.4,5.

TYPE LOCALITY. Off south of India, 430 fathoms (878 m).

Material examined: Malagasy: 15° 19′S & 46° 11′08″E, 405 m; 15° 19′01″S & 46° 11′08″E, 400 m; 23° 36′01″S & 43° 31′E, 445 m. Total 3 specimens.

Powell (1969) reported the species only from India and Indonesia, and the Malagasy record extends the species range into the southwest Indian Ocean. Specimens examined were uniformly pale orange-brown in colour and the spiral threads over the shoulder sulcus were either distinct or obsolete. Largest specimen examined measured 58.0 mm in length.

Genus **Marshallena** Allan, 1927

Marshallena Allan, 1927, Trans.N.Z.Inst. 57:291. Type species by SD (Finlay, 1927) *Belophos incertus* Marshall, 1919 = *Daphnella neozelanica* Suter, 1917. Tertiary of New Zealand.

Powell (1966) cited *Daphnella neozelanica* Suter, as the type species by monotypy but later Powell (1969) amended this to a type selection by original designation. Allan (1927) cited 5 species in the genus *Marshallena* without actually selecting a type species for the genus, and the type species was subsequently selected by Finlay (1927).

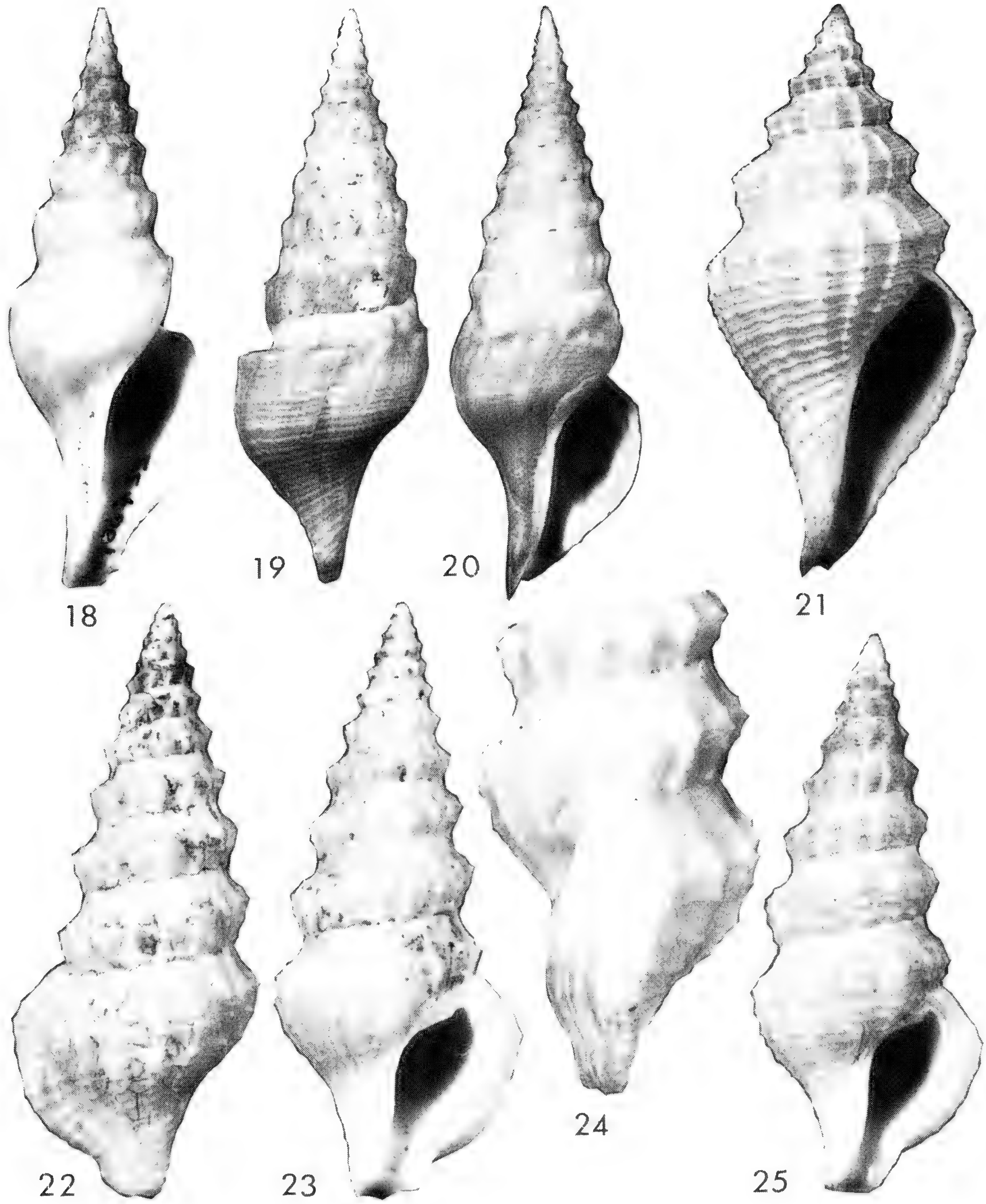
Marshallena philippinarum (Watson, 1882) (Fig.21)

1882. *Fusus* (*Metula*) *philippinarum* Watson, J.Linn.Soc.London 16:373; 1886 Watson, Sci.res."Challenger" Exped.Zool. 15:210, pl.12, fig.1.
1969. *Marshallena philippinarum* (Watson), Powell, Indo-Pacif. Moll. 2(10):369, pl.277, figs.7-11; pl.278; 1973 Kilburn, Ann.Natal Mus. 21(3):572, fig.13b.

TYPE LOCALITY. St.210, Philippine Islands, 9° 26′N & 123° 45′E, 375 fathoms (686 m), mud.

Material examined: Malagasy: 15° 19′01″S & 46° 11′08″E, 400m. A single specimen, length 15.8 mm.

Kilburn (1973) was the first to report a southwest range extension on the basis of a single specimen taken 100 km east of Inhaca I, southern Mozambique, in 476 m. The Malagasy record confirms the existence of *M.philippinarum* in East African waters.



Figs. 18-25. 18. *Comitas kaderlyi* (Lischke). Malagasy, 450 m; 74.3 mm. 19,20. *C.eurina* (E.A. Smith). Malagasy, 400-405 m. 19. 53.3 mm. 20. 57.5 mm. 21. *Marshallena philippinarum* (Watson). Malagasy, 400 m; 15.8 mm. 22-25. *Horaiclavus* (*Anguloclavus*) *multicostatus* (Schepman). 22,23. Malagasy, 405 m; 26.2 mm. 24. Side-view of a 17.6 mm specimen. 25. Malagasy, 445 m; 20.9 mm.

Subfamily DRILLIINAE Olsson, 1964

This subfamily name replaces the homonymous Clavinae Casey, 1904 (non McCrady, 1859). It should be noted that Drilliinae Olsson, 1964, has chronological priority over Drilliinae Morrison, 1966.

Genus **Horaiclavus** Oyama, 1954

Horaiclavus Oyama, 1954, Palaeont.Soc.Japan Spec.Pap.No.2:52. Type species by OD *Mangilia splendida* A.Adams, 1867. Recent, Japan.

Subgenus **Anguloclavus** Shuto, 1983

Anguloclavus Shuto, 1983, Mem.Fac.Sci.Kyushu Univ.,ser.D,Geol. 25(1):9. Type species by OD *Mangilia multicostata* Schepman, 1913. Recent, Indian Ocean.

Horaiclavus (Anguloclavus) multicostatus (Schepman, 1913) (Figs.22-25)

1913. *Mangilia multicostata* Schepman, Siboga Exped. 49:432, pl.28, fig.12.
1983. *Horailavus*[sic] (*Anguloclavus*) *multicostatus* Schepman, Shuto, Mem.Fac.Sci.Kyushu Univ.Geol. 25(1):10, pl.1, figs.9,10, textfigs.6/6-10.

TYPE LOCALITY. St.260, near north point of Nuhu Jaan, Kei Islands [Indonesia], in 90 m.

Material examined: Malagasy: 23°36′01″S & 43°31′E, 445 m; 15°19′S & 46°11′08″E, 405 m. Total 4 specimens.

Powell (1966) listed *Horaiclavus* Oyama, to be doubtfully turrid, since there was no vestige of a sinus on the outer lip. Three of the four specimens examined have a partially broken peristome and thus an undefined sinus, but one specimen with a complete peristome shows a shallow sinus of about the same magnitude as some species of *Marshallena* Allan or *Pusionella* Gray (Fig.24). Some species of the mitromorphine genera *Mitromorpha* Carpenter or *Mitrolumna* Bucquoy, Dautzenberg and Dollfus, show only an obsolete, almost imperceptible sinus. The radula of *Horaiclavus* has, however, been confirmed as toxoglossate (Kuroda, Habe & Oyama 1971). Shuto (1983) subsequently reported the species from *c*. 240 km N. of Coburg Peninsula (9°17.5′S & 132°20′E), Northern Territory, Australia (one holed specimen). He acknowledged the species as turrid on the basis of a toxoglossate radula in *Horaiclavus splendidus* (A.Adams), and created the subgenus *Anguloclavus* for *Mangilia multicostata* Schepman.

The four Malagasy specimens range in size from 17.6 mm — 26.2 mm, with 8½-10¼ whorls of the teleoconch and a protoconch of 1¾ whorls; the number of axial ribs on the penultimate whorl varies from 13-16. Sculpture is variable, some individuals have 4-5 spirals on the anterior two-thirds of the spire whorls more distinct than others. The outer lip is prominently varicose and the peristome is rather fragile,

the aperture is edentulous except for the parietal swelling and the columella is calloused. The colour is uniformly cream and the aperture white.

The Malagasy record is a considerable geographic as well as bathymetric range extension for the species.

Acknowledgements. I would like to thank Prof. A. Crosnier for having collected and made available the Malagasy Turridae with exceptionally accurate collecting data, and Dr. R. Tucker Abbott, formerly of the Delaware Museum of Natural History, Greenville, Delaware, for the loan of the collection to our Museum. I am grateful to Dr Subba Rao, Zoological Survey of India, Calcutta, for the loan of the holotype of *Gemmula congener* (E.A. Smith).

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ADDITIONAL NOTES ON *Livoneca neocyttus* (ISOPODA: CYMOTHOIDAE)

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Abstract. Additional descriptive notes are given from New Zealand specimens of *Livoneca neocyttus* Avdeev, 1975 an ectoparasite of deepwater oreosomatid dories. The host/parasite relationship is discussed in terms of specific hosts, site selection and host tissue damage.

Livoneca neocyttus Avdeev, 1975 was described briefly from specimens found as parasites of the oreosomatid dory *Neocyttus rhomboidalis* Gilchrist, 1906 in the New Zealand region. Since that time a number of deepwater fishing surveys off these coasts, completed as a preliminary to the declaration of Territorial Sea and the exploration of a 200-mile Exclusive Economic Zone, have produced a wider base for data collection. Samples of fishes, particularly dories, were used here to obtain specimens of cymothoid parasites, and to reassess the distribution and host specificity of these isopods. Specimens of *Livoneca neocyttus* were recovered from three genera of oreosomatid dories, *Allocyttus* sp., *Neocyttus rhomboidalis* and *Pseudocyttus maculatus* Gilchrist, 1906 but were notably absent from the related deepwater zeid *Cyttus traversi* Hutton, 1872.

Somewhat more detailed accounts of morphometric and meristic characters of *Livoneca neocyttus* are given here after a study of specimens from a wider range of the life history than reported by Avdeev (1975). Marsupial post-hatch larval states are described for the first time. Like other cymothoids, *L.neocyttus* is a protandrous hermaphrodite; the roles of female dominance and site selection as evidenced from capture records are discussed.

Family CYMOTHOIDAE

Genus **Livoneca** Leach, 1818

The spelling of the genus *Livoneca* Leach, 1818 deserves further comment since some recent authors, Bowman (1960), Trilles (1973, 1976), Avdeev (1975, 1978), Brusca (1981), indicate that by following Leach's usual pattern of anagrams the genus word *Livoneca* constitutes an incorrect original spelling and should be written as *Lironeca*. Justification for this arrangement was given by Monod (1931), who cited several ink corrections, reputedly in Leach's handwriting, to an offprint of Leach (1818) in the library of the Paris Museum. However, a modern interpretation (Article 32, International Code of Zoological Nomenclature) would regard those corrections as existing in manuscript form only and do not constitute publication. The original

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spelling of the genus *Livoneca* is used here and a recent explanation of Leach's names (Holthuis 1978) for a number of cymothoid genera is followed.

Livoneca neocyttus Avdeev, 1975 (Figs.1-10)

Livoneca neocyttus Avdeev, 1975, *Parazitologiya* (*Leningrad*) 9(3):247-251 figs. 1,2.

FEMALE

A large sized cymothoid isopod (Fig.1), total lengths for ovigerous females 48-66 mm. Body narrowly elliptical reaching greatest width over pereonite 5. Cephalon broadly triangular, blunt at apex, width 1.2-1.5 times length. Eyes oval, set at postero-lateral corners, moderately large but occupy proportionally less of head with increasing body size. Antenna 1 of eight segments, antenna 2 of fourteen segments; basal segments of antennae separated. Maxilliped (Fig.2) broadly expanded in ovigerous females, weakly setose along the anterior border. Maxilla 2 (Fig.3) with minute surface sculpturing, terminated by four stout curved hooks. Maxilla 1 (Fig.4) with five (2+3) apical hooks. Mandible (Fig.5) glove-like, terminated by a single blunt spine; mandibular spines meet in opposition at body midline. Mandibular palp of three segments, terminal article weakly setose, especially in smaller size individuals. Pereon segments minutely stippled in patches; patches occupy less surface area on each successively posterior segment. Pereonite 5 widest and longest, pereonites 1,3,4,6 subequal, pereonites 2 and 7 are shortest. Antero-lateral angles pereonite 1 acute, junction with cephalon weakly sinuate. Antero-lateral edges pereonites 2,3 and occasionally 4,5 are raised, almost bulbous. Pereonites 4-7 with a shallow transverse groove towards each postero-lateral angle. Epimera of pereonites 2-7 relatively inconspicuous when viewed from above; but increase in surface area posteriorly, rarely overlapping.

Pereopods of similar size but progressively larger from pereopod 1 to pereopod 7. Prehensile basos of all pereopids with non-tubercular carina, last four pairs strongly carinate.

Five imbricating pairs of oostigites in ovigerous females, developing anteriorly in an alternating sequence from posterior right, which is also outermost.

Pleonites sub-equal in length, partially overlapped by pereonite and coxa of segment 7. Pleon slightly raised in dorsal midline forming a short, flattened ridge. Pleopoda similar in shape, slightly decreasing in size posteriorly. Appendix masculina of pleopod 2 (Fig.6) can persist into late developmental stage of female. Inner basal segment margin of pleopods 1-4 fringed with 7-12 natatory hairs. Pleotelson dome shaped, posterior margin usually symmetrical. Uropoda relatively small, not easily seen from dorsal aspect and tending to lie under the curved pleotelson margin. Exopoda only fractionally longer than endopoda.

MALE

Males relatively large, total lengths 20-39 mm, general body shape narrowly eliptical. Pleonites not abruptly narrower than pereonite 7.

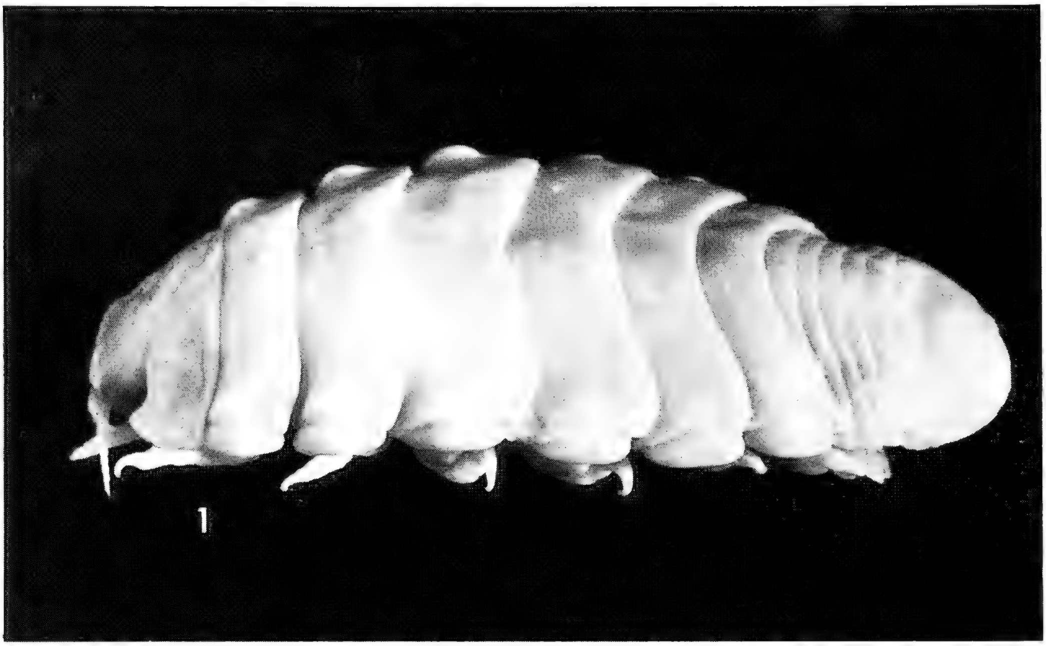


Fig. 1. *Livoneca neocyttus.* Dorso-lateral view of mature female.

Cephalon broadly triangular, broadly rounded at apex, and immersed in first pereonite. Eyes occupying proportionally greater area of head than in females. Antenna 1 of eight articles, segments 4-8 inclusive bear clusters of setae, directed posteriorly; one or two degenerate spines on segment 3 and segment 8. Antenna 2 of fourteen segments (6+8), degenerate natatory hairs persist on segments 4-6 inclusive. Mouth parts generally as described for females. Maxillipeds slender and exopoda rudimentary. Mandibular palp armed with short spines, eleven on segment 2, and six on segment 3; three apical flagella present.

Pereonites 3,4,5 widest, but when viewed inclusive of epimera (which increase in area, posteriorly) the pereon appears more or less straight-sided. Pereopods of similar shape increase slightly in size posteriorly. Basos of pereopods with low carina. Pereopods 4-7 with a few short spines occurring distally on ischium, merus, carpus and along inner border of propodus; their presence and numbers not consistent amongst all males.

Pleonites exposed with pleopoda of similar form to those of females. Appendix masculina on pleopod 2 reaches to lower edge of endopod in larger males. Short degenerate hairs may persist along inner margines of endopoda of pleopoda 2.

JUVENILES

A discussion of juvenile stadia is somewhat restricted by the availability of material. Only six larviparous females were studied and free-living juveniles were not

seen amongst potential host fishes. Marsupial post-hatch ("post-manca" Brusca 1978) generally resemble slender males, though at least two stadia or instars could be identified. Within any one brood pouch the oldest post-hatch were at the same stage of development even though individuals varied slightly in total body length.

First instar. Total lengths 5.9-7.0 mm. Cephalon pointed apically almost triangular. Eyes occupying a very large area of dorsolateral surface. Body slender, straight sided, widths of pereon and pleon more or less the same. Seventh pereon segment generally incomplete, exceptionally short, segmentation from segment six often difficult to distinguish. Seventh pair of pereopods absent. Precursory hairs visible through unpigmented segment walls of the appendages.

Second instar. Total lengths 6.2-7.3 mm. Cephalon broad apically, profile more semicircular than triangular. Eyes less prominent than those of the first stadia. First antenna of eight segments bearing clusters of short spines and flagella (Fig.7). Second antenna with thirteen segments with natatory hairs and short spines on all but the proximal three segments (Fig.8). Mouth parts similar to males but terminal hooks on maxilliped and maxilla not strongly developed. Mandible (Fig.9) with a palp bearing flagella and short setae on segments 2,3. Segment 2 with 11 short setae, segment 3 with 6 short setae and 3 flagella.

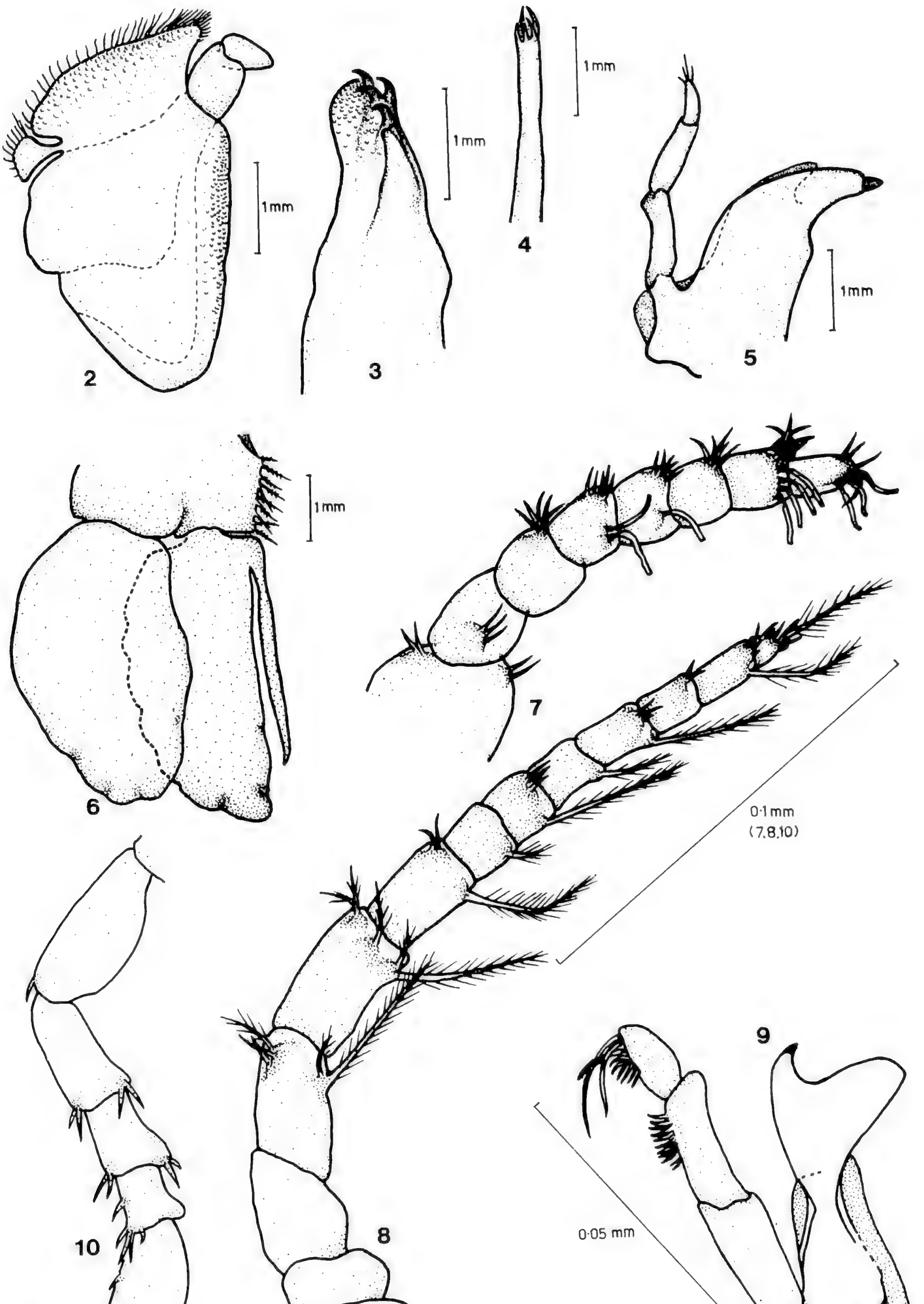
Body shape elliptical, pereon segments increasing in width, posteriorly to segment 6. Pereopods more or less of equal size armed with short spines (Fig.10). Seventh pereonite, immature, distinctly shorter, seventh pereopods undeveloped.

Pleon and pleopoda as in males but appendix masculina absent. Telson and uropoda bear marginal natatory hairs and spines. Numbers from counts of a dissected specimen (TL 6.3 mm): exopoda hairs 26, spines 7; endopoda hairs 22, spines 1; telson hairs 32. Telson with patches of short hairs over dorsal surface.

DISTRIBUTION. Specimens of *L.neocyttus* collected in this study came from exploratory fishing over continental slope topography (470-930 m) to the south-east of New Zealand, including areas of the Chatham Rise, Pukaki Rise and Bounty Plateau. Since that time oreosomatids have been fished from a number of additional areas, generally in the depth range 500-1100 m, including the Wairarapa Coast, Colville Ridge, Whanganella Bank and the Campbell Plateau. Although no evaluation of records of parasites has been available to date, the potential for a much wider parasite distribution would seemingly be available throughout the New Zealand region.

Material examined

1 ♀ 1 ♂ Chatham Rise 42°51′S, 178°61′E, 508 m Shinkai Maru Stn 51 9 Nov 1975. 1 ♀ Chatham Rise 43°07′S, 179°47′E, 550 m Shinkai Maru Stn 61 11 Nov 1975. 1 ♀ Chatham Rise 42°48′E, 178°27′E, 925 m Shinkai Maru Stn 15 Nov 1975. 1 ♀ Chatham Rise 42°54′S, 175°22′E, 582 m Shinkai Maru Stn 27 Apr 1976. 2 ♀ 1 ♂ Chatham Rise 42°50′S, 176°22′E, 552-520 m Shinkai Maru Stn 75 19 May 1976. 1 ♂ Chatham Rise 44°28′S, 174°38′E, 750 m Shinkai Maru Stn 226 8 Jan 1977. 1 ♀ 1 ♂ Pukaki Rise 48°54′S, 175°39′E, 930-912 m Shinkai Maru Stn 241 12 Jan 1977. 19 ♀ 12 ♂ Chatham Rise 44°00′, 177°54′E, 998-813 m Kaiyo Maru Stn 26 22 Dec 1977. 1 ♀ Chatham Rise 44°03′S, 179°06′E, 750 m Wesermunde Stn 030 27 May 1979.



Figs. 2-10. *Livoneca neocyttus*. 2-5. Female mouthparts. 2. Maxilliped. 3. Maxilla 2. 4. Maxilla 1. 5. Mandible. 6. Mature female, pleopoda 2 showing persistent appendix masculina. 7-10. Juvenile. 7. antenna 1. 8. Antenna 2. 9. Mandible. 10. Pereopod 5.

Host specificity. A general survey for isopod parasites amongst the New Zealand deepwater fish fauna suggests *Livoneca neocyttus* has a narrow range of hosts, these being limited entirely amongst oreosomatid dories. Avdeev (1975) reported *Neocyttus rhomboidalis* as the sole host fish species, but in this study adults of three oreosomatid genera; *Allocyttus* sp. (TL.19-44cm), *Neocytus rhomboidalis* (TL.15-35cm) and *Pseudocyttus maculatus* (TL.17-43cm) have been found as hosts.

The levels of parasitism within these host fishes showed considerable variation; *Allocyttus* sp. (n=64) fish with parasites 26, *N.rhomboidalis* (n=52) fish with parasites 4, *P.maculatus* (n=40) fish with parasites 3. Because of small sample sizes and mixed (non-random) sampling methods no conclusion can be drawn from these results; both live capture and selective preserved material are included in these data. The results given by Avdeev (1975) suggesting an infestation level of 30% in *N.rhomboidalis* (n=30) appear to have similar disadvantages against interpretation.

Amongst other potential fish hosts it was found that the zeid dories, particularly *Cyttus traversi* captured from the same location and over depth ranges 80-600 m, were parasitised only by the more widespread cymothoid *Livoneca raynaudii* Milne Edwards. Avdeev (1975) reported similar results from fishes examined for his study.

DISCUSSION

Site Selection

Livoneca neocyttus is a protandrous hermaphroditic parasite in which a single maturing, or ovigerous female occupies the host's buccal cavity, while males and juveniles are restricted to skin sites near the branchial arches and/or the opercular membrane. Unlike many other instances of cymothoid parasitism, the host's tongue (glossohyal/hyal apparatus) is not used as a principal site of attachment by females. They instead attach to the soft membrane lining the room of the buccal cavity facing towards the host's mouth opening. This specific site of attachment and orientation was common to twenty-eight of the thirty-three females recovered. As a principal position it nevertheless provides best environmental circumstances, first use of water and food supply. The situation also has an upstream advantage in the probable chemical control ("neurohormonal" Trilles 1969; "exogenous stimuli" Brusca 1978) over individuals in posterior, branchial or opercular sites. When present, an accompanying juvenile or male (rarely more than one specimen) generally occupied a posterobuccal position, near the gill arches, rather than alternative potential sites on the gill lamellae or linings to the opercular chamber.

Site damage

Instances of skin and gill damage reported widely amongst hosts of other cymothoid isopods (Stephenson 1976, Brusca 1981) were generally not prevalent

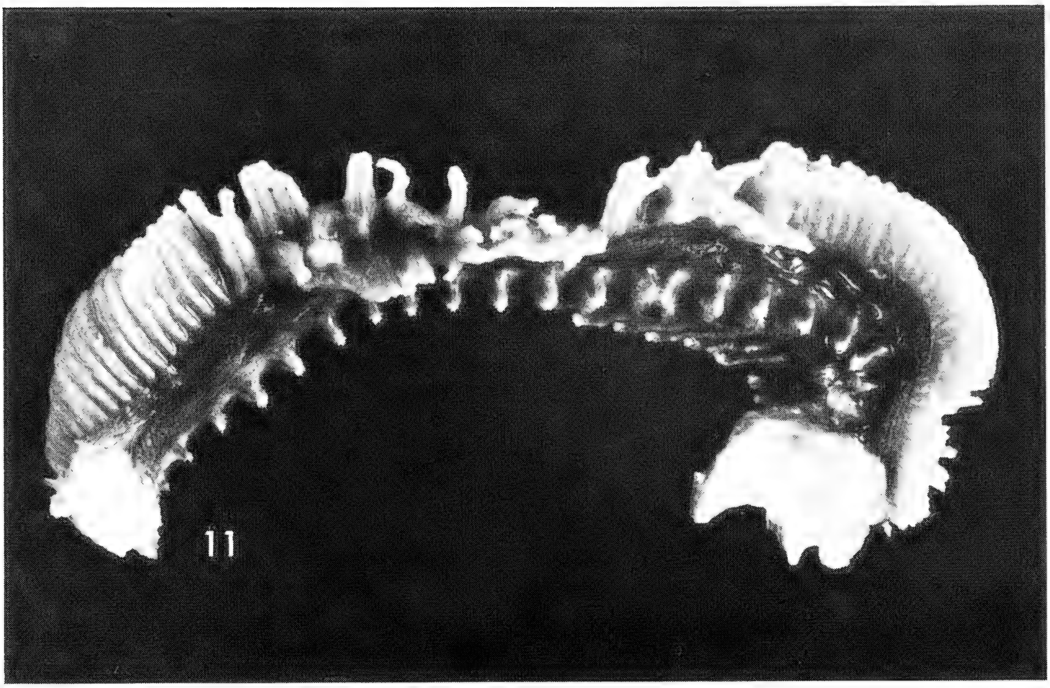


Fig. 11. *Neocyttus rhomboidalis.* Excised first branchial arch (left side) showing gill filament contact damage.

amongst fish studied in this report. Slight skin abrasion together with a patch of clotted blood, somewhat imprinting the parasite's ventral head and thoracic regions, was apparent on the removal of some females. One instance of gill filament distruption (Fig.11) was recorded after the removal of a male from an adjacent attachment site in the branchial chamber. Damage here did not extend beyond the area of immediate contact.

It seems likely that in oreosomatid dories the relatively large volume of the buccal chamber, together with *L.oreosoma* having sites of attachment generally not including the tongue or branchial arches, are features that reduce the potential for physical damage. Of particular interest, however, is that the oreosomatids have stubby and sharply ornamented gill rakers. From a parasite perspective the selection for suitable sites of attachment may not necessarily be those of the highest preference but those governed by the need to avoid the gill rakers.

Acknowledgements. Assistance with specimens has come from various sources: T. Inada and T. Arai, Japan Marine Fishery Resource Research Centre; G. James, Fisheries Research Division; J. Moreland and C.D. Paulin, National Museum of New Zealand; their help is gratefully acknowledged.

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A NEW GENUS OF COLLEMBOLA (NEANURIDAE:NEANURINAE) FROM SOUTHERN NEW ZEALAND

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Abstract. A new genus and species, *Zelandanura bituberculata* is described. It is recorded from Campbell Island south of New Zealand. This genus and *Australonura* Cassagnau, 1980 form a distinct southern hemisphere line within the Neanurinae.

Résumé. Une nouvelle espèce appartenant à un nouveau genre, *Zelandanura bituberculata*, est décrite dans ce travail. Ce genre et *Australonura* Cassagnau, 1980 forment une lignée particulière à l'hémisphère austral au sein des Neanurinae.

Specimens previously recorded from Campbell Island, south of New Zealand, are now found to be an undescribed species.

Genus **Zelandanura** gen. n.

Blue pigment absent, animal white in alcohol. Ant.III organ complete(5s-setae). Ant.IV with s1 to s8 subequal and apical vesicle entire. Eyes 2+2, without dark pigment. Labrum chaetotaxy: 0/2,4. Maxilla styliform. Mandible slender, with 2-3 teeth. All dorsal tubercles present, with reticulations and medium sized tertiary granulation.

Dorsal tubercles distributed as follows.
Head. 7 tubercles: Cl,(Af+2Oc), (Di+Di), 2De, 2 (L+D1+So).
Tergites. All tubercles separated on Th.I-Abd.III. On Abd.IV, Di fused together mid-dorsally; De, Dl and L separated. On Abd.V, (Di+De+Dl) fused together. On Abd. VI, tubercles fused together mid-dorsally.

Clothing not plurichaetotic. S-setae present in standard number and arrangement, 2+ms,2/1,1,1,1,1 on each half tergite from Th.II to Abd.V. Claw without inner tooth.

Type species. Zelandanura bituberculata sp.n.

Zelandanura bituberculata sp.n. (Figs. 1-7)

Length 1.3 — 1.9 mm. Habitus contracted, slightly convex. Tertiary granulations medium-sized; reticulations obvious. Long macrochaetae thick, smooth, strongly clavate. Ant.III guard setae of normal size as are s1 to s8 of Ant.IV. Apical vesicle of Ant.IV entire. Labrum elongated, with ventro-distal sclerotisation arcuate. Chaetotaxy and tubercles as in Table 1 and Fig.1. All setae within tubercles, except Di3 on Th.III and sometimes on Th.II. Claw without internal tooth. M-seta absent on tibiotarsus.

Holytype. Campbell I. Tucker Cove, under timber, 28.II.1963, K.A.J. Wise (deposited in Auckland Museum, Auckland).

Paratypes. Seven, same data as holotype (distributed in Bernice P. Bishop Museum, Honolulu, Université Paul Sabatier, Toulouse and Auckland Museum).

Table 1. Chaetotaxy of *Zelandanura bituberculata* sp.n.

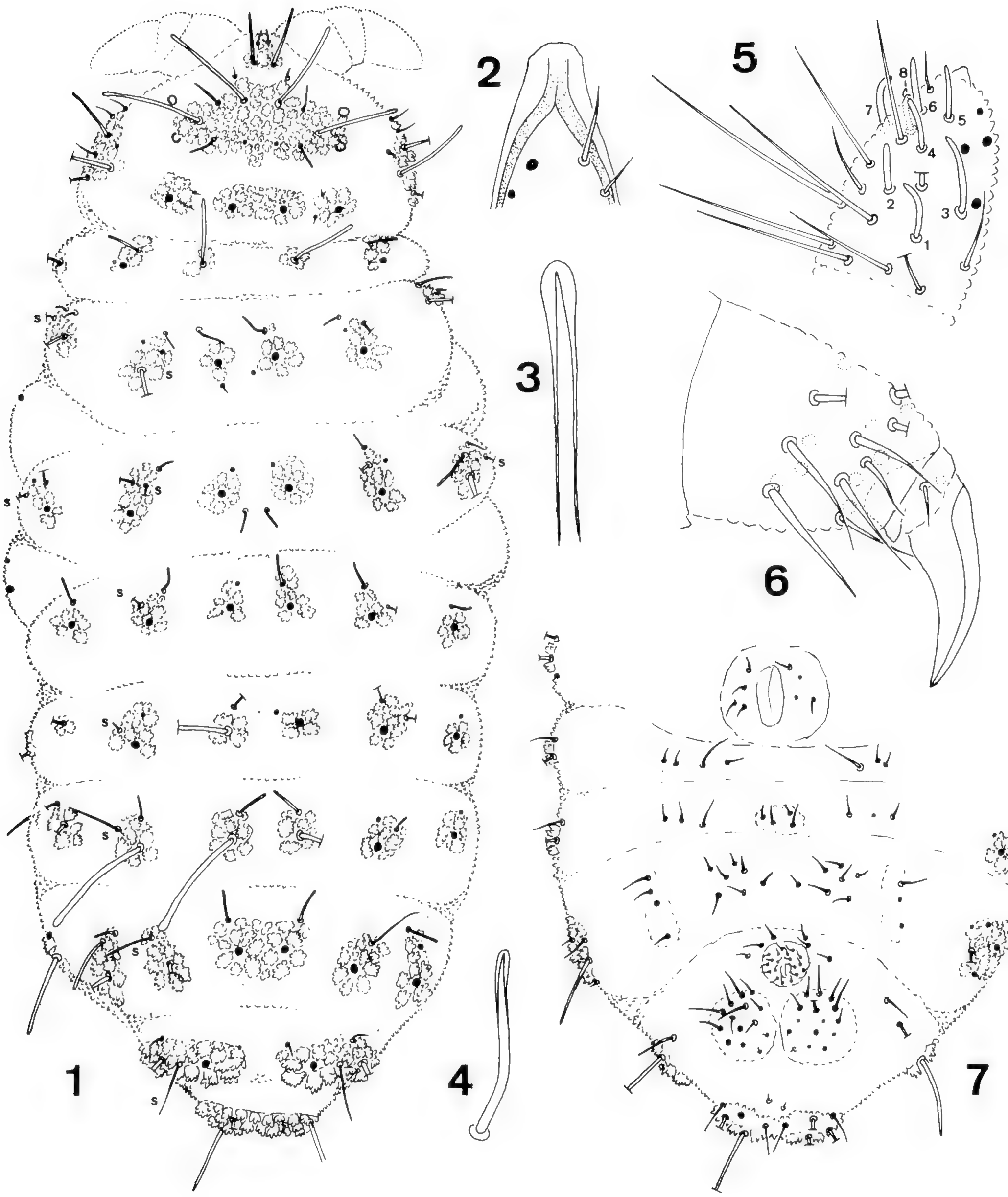
Chaetotaxy of the head

Group of setae	Tubercle	Setae number	Kind of setae	Setae
Cl*	+	4	Ml	F
			me	G
Af+2Oc	+	14	Ml	B,Ocm
			Mc or me	A,D,E,Oca,Ocp
Di+Di	+	2	Ml	Di1
De	+	3	Ml	De1
			Mc or me	Di2,De2
Dl+L+So	+	>10	Ml	4
			Mc or me	>6

Chaetotaxy of the body and the legs

	Di	De	Dl	L	Scx2	Cx	Tr	F	T
Th.I	1	2	1	—	?	?	?	?	18
II	3	3+s	3+s+ms	3	?	7	?	?	18
III	3	3+s	3+s	3	?	?8	?	?	17
Abd.I	2	2+s	2	3	TV: 4				
II	2	2+s	2	3	Ve: 4(Ve1 present)				
III	2	2+s	2	3	Fu: 3-4me,Omi		Ve: 3-4		
IV	(2+2)	1+s	3	6	Ve: 7-8		Vl:3-5		
V	—	6+s	—	1-2	Ag: 3		V1: 0		
VI	(7+7)	—	—	—	Ve: 12-14		An: 2mi		

* Cl is fused with (Af+2Oc) in 1 specimen.



Figs. 1-7 *Zelandanura tuberculata* sp.n. 1. Dorsal. 2. Apex of labrum, dorsal. 3. Long clavate macrochaeta of Abd.III. 4. Short macrochaeta of Abd.III. 5. Ant. IV, dorsal. 6. Claw and tibiotarsus of leg I. 7. Abdomen, ventral.

Derivation. Zelandanura, New Zealand species without a furca; *bituberculata* refers to the fusion of tubercles into one tubercle on each side of Abd.V.

Zelandanura gen. n. and the genus *Australonura* Cassagnau, 1980 together constitute a southern hemisphere line characterised by the simple median tubercle (Di+Di) of the head. The two genera differ in the arrangement of tubercles on the posterior tergites. In *Australonura*, the tubercles Di of Abd.V are fused on the median dorsal line. In *Zelandanura*, however, the tubercles Di of Abd.V are separated at the median line and are fused laterally with De and Dl.

This species was previously recorded from Campbell Island by Wise (1964) as *Neanura radiata* Salmon, 1941. It is likely that the specimens were introduced from New Zealand. The original specimens recorded by Wise have been examined and are considered to be the present species. *Z. bituberculata* sp.n. differs from *Crossodonthina radiata* (Salmon, 1941) [= *Neanura radiata*] and other New Zealand Neanurinae species in the pattern of the tubercles and other characters.

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The opportunity to work on these Collembola, from the collections of the Bernice P. Bishop Museum, Honolulu, Hawaii, is appreciated.

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PREHISTORIC ARCHAEOLOGICAL SITES ON THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

BRUCE W. HAYWARD

NEW ZEALAND GEOLOGICAL SURVEY, LOWER HUTT

Abstract. Archaeological features present on the four largest islands indicate that Maoris permanently occupied the Three Kings Group for one or more periods in prehistoric time. Common elongate, hillside terraces, stonework (heaps, rows, retaining walls), and shallow boundary ditches, together with early European reports (pre 1800) show that extensive areas were cleared of forest and cultivated on Great, North East and probably South West Islands. The lack of pits may indicate that the climate was warm enough for crop storage above ground or that kumara could be grown year round.

Clusters of smaller terraces, often with stonework and sparse midden, probably represent the sites of shelters adjacent to the gardens. A concentration of these features in Castaway Valley and on the northern side of South East Bay is interpreted as the main undefended dwelling area. Several small terraces on remote West Island may be the sites of temporary shelters used by short-term mutton-birding parties. No pa are present on these islands. Their isolation may have been considered sufficient defence.

Prehistoric clearance of most of the forest had an enormous impact on the islands' biota and probably resulted in the extinction of a number of endemic plants and small animals.

Three Kings Islands are situated 40 km north-west of the northern tip of New Zealand. They consist of one large island (Great Island) of approximately 300 ha, three smaller islands (North East, South West and West) each of 20-80 ha, and numerous sparsely vegetated or bare rocks (Fig. 1). All are surrounded by cliffs that drop straight down into deep water and therefore landing points and routes up to the flatter, vegetated tops are few. The large ocean swells and frequently rough sea conditions in the area often make these landings impractical, except in the lee of Great I.

The extent and purpose for which these islands were used by the prehistoric Maori is of considerable interest because of their isolation, their location at the extreme northernmost tip of New Zealand, and the impact man may have had on their endemic flora and fauna.

Historical records

Little is recorded of the traditional history of prehistoric use of the Three Kings Is. The last Maori (Tom Bowline) known to have lived on the islands told the Maori Land

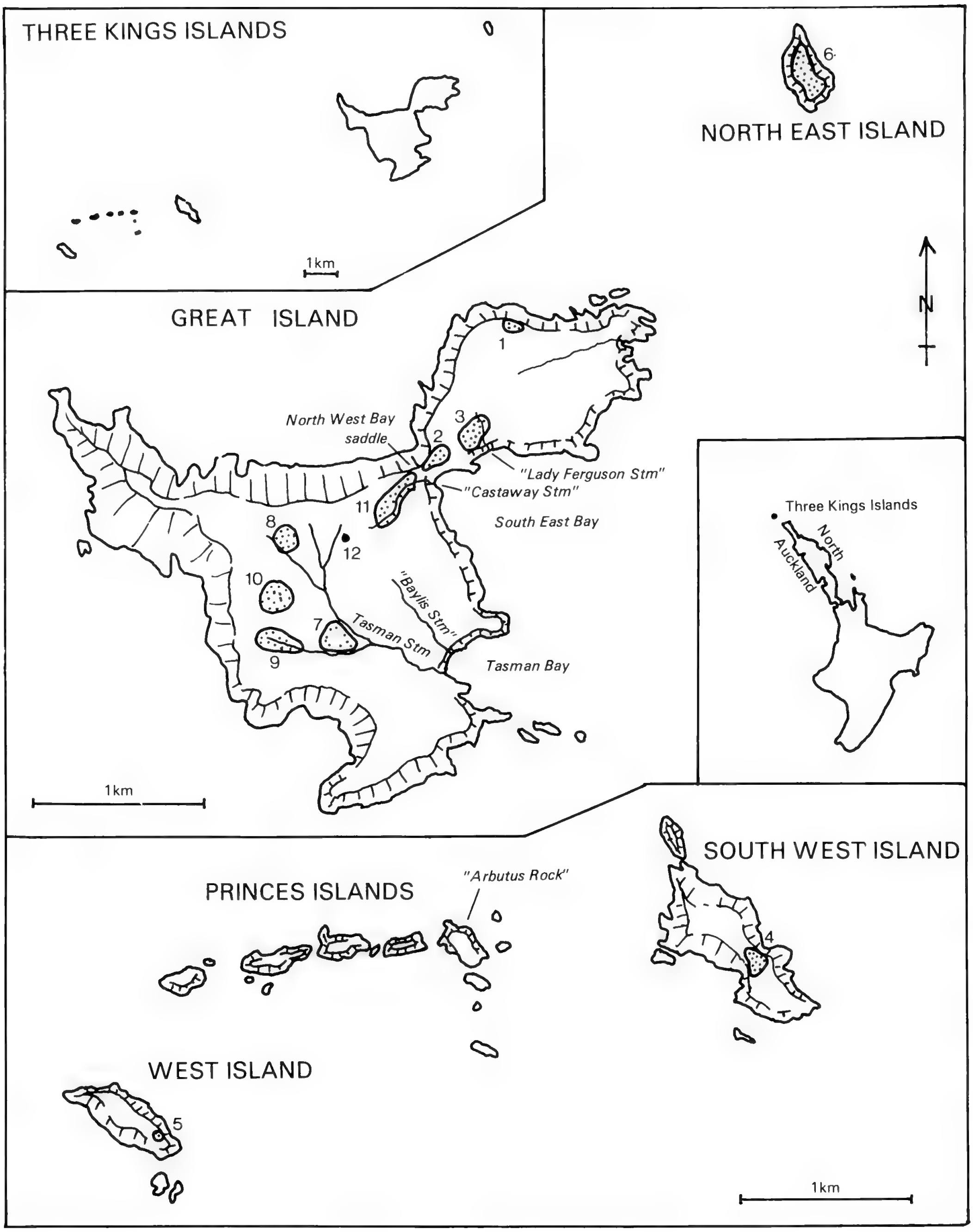

Fig. 1. Map showing distribution of recorded archaeological features (dotted and numbered) on the Three Kings Is. Inset location map.

Court that they were once inhabited by about 100 people led by Toumaramara. These people were reportedly attacked and massacred by a party of Aupouri led by Taiakiaki in the late eighteenth century (Cheeseman 1888).

Recorded European observations predate this event by at least a century. Abel Tasman anchored off the islands in January 1643 and his men made several unsuccessful attempts to land and fill their casks with water from the small waterfall in Tasman Bay on Great I. In his journal, Tasman (Heeres 1898), wrote . . . "in rowing round the island our men nowhere saw any dwellings or cultivated land, except just by the fresh water [Tasman Valley] . . . where higher up on both sides of the running water, they saw everywhere square beds looking green and pleasant." The sailors saw 30 to 35 Maoris on shore, some of whom threw stones at them as they rowed in close. In Tasman Bay they saw two canoes hauled up on the rocks, one seaworthy, the other broken (Heeres 1898).

The next recorded European visit was that of Marion du Fresne in April 1772 (Roth 1891). He saw people on Great I which he said . . . "appeared to be most extraordinary, in view of the apparent barrenness of the country." Twenty years later another passing mariner, d'Entrecasteaux, wrote: ". . . a large column of smoke arising from the easternmost islet informed us that there were savages on it" (La Pérouse 1799). Buddle (1948) realised that this is the only known reference to Maoris on North East I.

Between 1800 and 1830, parties of Aupouri made occasional visits to the Three Kings but did not reside there permanently. In the 1830's Tom Bowline (who had married one of Toumaramara's grand-daughters) and his family of 12 children lived on Great I and established large gardens. These last Maori occupants left the Three Kings about 1840 (Cheeseman 1888). Since that time no one has lived on the islands, and only occasionally have visiting seamen and more recently scientists and lighthouse personnel landed. Even then, almost all landings have been on Great I.

Previous archaeological observations

The most significant factor bearing on the present and earlier observations of the archaeological features of Great I was the introduction of goats in the first part of the nineteenth century (Baylis 1948). By 1900 they had expanded to 300-400 animals. Their browsing had removed almost all the undergrowth and archaeological features were readily identifiable. The goats were shot out in 1946 and regeneration over the following years rapidly obscured most of the features. Today much of the surface archaeology is still hidden, and in many places the thick scrub makes movement and site location difficult.

Fraser (1929), who stayed for three days on Great I with a party led by Lady Fergusson, was the first to record, in general terms, the wealth of archaeological remains.

Archey (1948) described several pieces of carved totara and part of a coffin box that were recovered from two burial caves on Great I (L1/12) in 1946 by the goat extermination party. Archey himself visited Great I in 1951 and 1953 (unpublished notebook held in Auckland Museum), making notes on some of the surface features and excavating a terrace beside the Castaway depot and the floor of a rock shelter near Tasman Stream mouth. Bottle glass was found in the terrace excavation and charcoal was the only suggestion of human activity found in the rock shelter. A small party of archaeologists led by Ian Lawlor spent three days on Great I in 1979 and made detailed plans of several stonework features in Castaway and Tasman Valleys. A landing was also made on South West I and possible stonework features noted near the top at the northern end (Ian Lawlor pers. comm.).

The only other record of archaeological features on the smaller islands is that of Buddle (1948) who landed on North East I with Magnus Johnson in 1947 and 1948 and found extensive stonework features on the gently sloping top.

Present observations

The archaeological observations recorded here were made during a 5 day visit in December 1982 (Great and South West Is) and an 8 day visit in November — December 1983 (Great, North East, South West, West and Princes Is). Both trips were organised by the Offshore Islands Research Group. Site numbers given in this paper are those of the New Zealand Archaeological Association's site recording scheme and are prefixed by NZMS 260 map number L1.

ARCHAEOLOGICAL FEATURES

North East Island

North East I is completely surrounded by 70-90 m high, near vertical cliffs that drop straight into deep water. There are two landing points on the north tip and on the east side, where a relatively easy rock climb leads up to the vegetated top. These landings, especially the eastern one, are difficult or impossible in all but relatively calm conditions.

Fig.2. North East I from the east.

Stonework and terraces (L1/6) are spread over the entire two ha of gentle, east-sloping land on top (Fig.2). The surface stones on the almost flat northern portion have been gathered into several widely-spaced heaps and rows. The sloping central and southern portions have been modified by a series of at least 20 major terraces (each *c.* 20 x 5 m) and numerous smaller ones. In rocky areas these terraces have stone retaining walls and in several places there are also stone heaps (up to 2 m high and 4 m diameter) where the surface stones have been piled up on top of an original large boulder (Fig.3).

Great Island

Great I consists of a large southern area joined by a narrow, 80 m-high saddle to a smaller, nearly flat-topped, north-eastern part. The main southern portion is mostly rolling country (Fig.4) drained primarily by Tasman Stream, which provides year round fresh water. Two smaller seasonal streams (Castaway and Baylis Streams) drain its somewhat steeper, eastern slopes.

The northern, western and extreme southern sides of Great I are bordered by 100-250 m high near-vertical cliffs. On these sides a landing from the sea and route up the cliff, is only possible at two sloping rock shelves on the west coast and at a boulder and cobble beach in North West Bay, below the saddle. This is the only beach on the Three Kings but easy landings are still only possible in a low swell. The cliffs around the eastern side of the island are much lower and access from the sea is considerably easier (Figs.4,5) especially in Tasman and South East Bays. In most conditions a landing on Great I is possible, either in North West or South East Bays depending on the direction of the seas.

Fig.3. A 2 m high heap of stones beneath puka forest on the top of North East I.

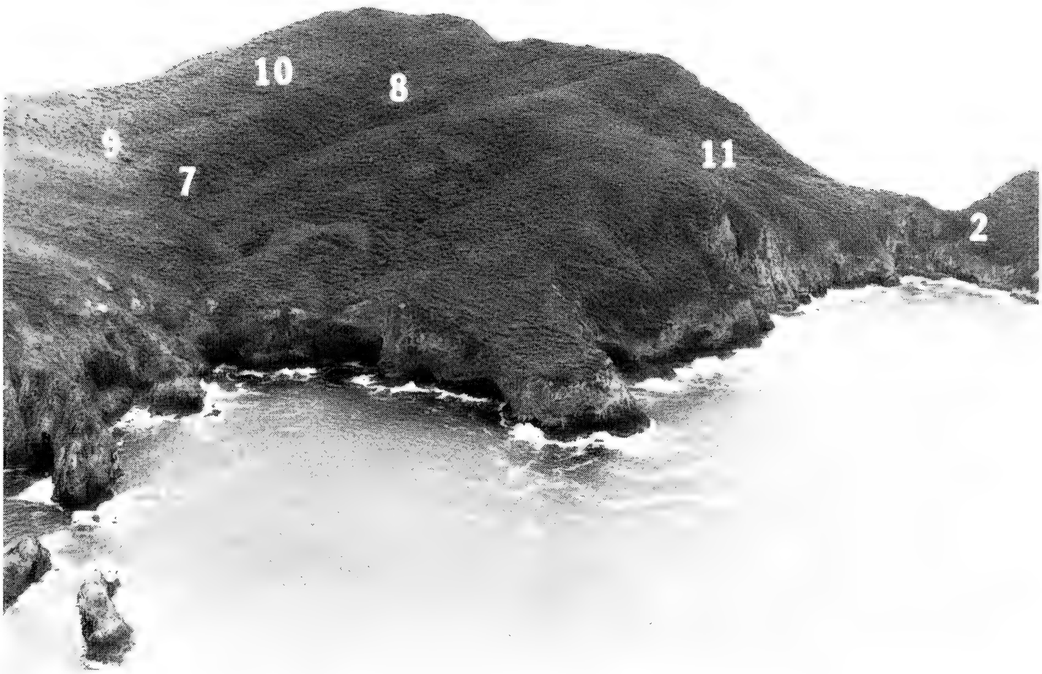

Fig.4. Oblique aerial view of main part of Great I with Tasman Bay (left) and South East Bay (right) in the foreground, Tasman Valley (left) and Castaway Valley (right in centre). Location of recorded sites is indicated.
Photo: Lloyd Homer, N.Z.G.S.

Tasman Valley. The largest areas of prehistoric archaeological features are in the headwaters and middle reaches of Tasman Valley. Today their full extent and density is hard to assess because of the thick ground cover and in places dense vegetation. Four major areas of flat or gently sloping land containing evidence of prehistoric use (L1/7-10) have been identified (Figs.1,4). Earlier reports from when goats were present (Fraser 1929), indicate that archaeological features are more widespread than this. The most common features are widely spaced heaps of stones and where the valley sides are steeper, elongate terraces. Fraser (1929) estimated from his observations of these features that the area of prehistoric cultivation in Tasman Valley was about 30 ha.

Two, broad, nearly flat valley floor sites (L1/7,9) are free of rocks but each has four, straight, parallel, shallow trenches (*c.* 0.3 wide, 0.1-0.3 m deep) set 10-20 m apart, that extend downslope across them for 60-120 m. On the steeper sides of these flats and in narrower portions of the stream valley there are a number of scattered, smaller terraces (*c.* 4-8 x 2-4 m). These areas are naturally more rocky and stone retaining walls are often present.

Fig.5. View across South East Bay (right) and the saddle to the north-east portion of Great I, with North East I beyond. Sites above South East Bay and in Lady Fergusson Valley are indicated.

Castaway Valley. The greatest concentration of stonework and terracing on Great I is on the floor and lower, east-facing slopes of Castaway Valley (L1/11, Fig.4). The hillside is covered by a series of 40-50, well-spaced terraces (each 5-20 x 2-5 m) extending up the valley between 100 and 180 m above sea level. Stone retaining walls (0.5 - 1.5 m high) are common. Stone heaps are uncommon, although one large heap above the Castaway depot is 5 m across and 2 m high. Near the upper limits of this area, the valley floor widens and two, parallel, 20 m long, stone rows (2 m wide, 1 m high) ascend the gentle slope.

Towards the middle of the area, a prominent terrace (25 x 25 m) with a stone retaining wall (Fig.6) has five identifiable whare sites (3-5 m square) arranged in a row along it. Three of these sites are outlined by one layer-high, stone rows and shallow drains that partly encircle each.

North east Great Island. The moderately steep, south-facing slopes above the landings in South East Bay have a number of small terraces (L1/2,3) especially on the gentler sloping spurs and adjacent to the saddle. Around many of these terraces lies scattered shell midden, from which Lady Fergusson's party found obsidian and an adze (Fraser 1929). An obsidian flake collected here by P.R. Moore in 1983 is green in transmitted light and therefore derived from either Kaeo or Mayor Island sources,

For cultural reasons, this image has been removed.
Please contact Auckland Museum for more information.

Fig.6. Part of a prominent terrace and stone retaining wall, Castaway Valley.

probably the former (P.R. Moore pers. comm.). Short, stone-retained terraces occur adjacent to several, semi-permanent pools of fresh water in the lower part of the small, Lady Fergusson Valley. Higher up, where the valley broadens out, two terraces (20 x 50 m) with 1.5 m high stone retaining walls, span its width.

The only other site (L1/1) located on the north east part of Great I consists of four, elongate terraces (each *c.* 100 x 8 m) that extend across the top of a gently sloping, basin-like valley atop the northern cliff.

Other sites. Several overhanging rockledges provide shelter on Great I. Although they were undoubtedly used by the prehistoric Maori, no direct evidence of this has been found despite Archey's 1953 excavation of one.

Two burial caves (L1/12) have been recorded on Great I (Archey 1948). These are low narrow, man-made caverns that extend 3 m beneath a large hillside boulder. In addition to human remains they contained a number of totara carvings, now in Auckland Museum.

South West Island

This is the second largest island in the group and like the others is surrounded by 80-160 m high cliffs. Landing is often possible in an enclosed gut at the northern end

from where access to the top of the island involves a 200 m scramble up a very steep slope. In the calmest weather landing can be achieved at the south east end (with an easy 20 m clamber on to vegetated slopes).

The only flat or gently sloping area on the island is on the main ridge crest, especially towards the southern end where it broadens out into a 2-3 ha plateau. The only archaeological feature identified on the island was a low stone retaining wall (L1/4) on the north-east edge of this plateau. The surface of this 120 m high flat is free of rocks and the rounded pebbles in the soil may be human additives or relicts from higher sea levels.

Princes Islands

The Princes Is are a chain of rocky, sparsely vegetated islets between South West and West Is. On most of them landings are often possible on the north side. The six largest of these were landed on by members of our 1983 party, but no archaeological evidence was seen. Rounded pebbles on steeply-sloping, Arbutus Rock (A.E. Wright pers. comm.), are thought unlikely to be human additives to improve the soil and are more probably relict terrace deposits or seal gastroliths.

West Island

West I is completely surrounded by 40-130 m high cliffs that drop away straight into deep water (Fig.7). Landings can be made at a number of places around the bottom of the cliff but access up them to the vegetated area is limited to the southern end and a vegetated gut on the west side. Strong tidal currents, prevalent large swells and stormy weather make landing on this island the most difficult in the group. The island is entirely cliffed along the north and east sides and slopes steeply away from the narrow clifftop crest to the south and west.

Archaeological features were only seen on a gently sloping, slightly broader area of the crestal ridge above the southern landing (Fig.7). Here there are five, man-made terraces (each *c.* 8-15 x 3-5 m) several with 0.3 m high, stone retaining walls, and scattered shell midden, charred hangi stones and charcoal (L1/5).

INTERPRETATION OF THE ARCHAEOLOGY (Fig.8).

Canoe landings

The presence of archaeological features on the four largest islands shows that the prehistoric Maori made considerable use of the group, despite its isolation and the difficulties of landing. Probably the greatest obstacle to overcome was landing from a wooden canoe and hauling it ashore on the steep, rocky coast. This would usually be possible on the lee side of Great I where there are sloping rock shelves in Tasman Bay, South East Bay and at two places on the west coast or on the beach in North West Bay. Hauling a canoe up onto the rocks at the north ends of North East and South West Is

Fig.7. View from the south-west of West I and two of the Princes Is beyond. One site is indicated.

Photo: Lloyd Homer, N.Z.G.S.

would only be possible in calm conditions and very rarely possible on the east side of West I. If high seas came up however, it would be almost impossible on these smaller islands to haul canoes up the cliffs above the waves. Canoes may therefore have been based on Great I and used to ferry people to the smaller islands when conditions allowed.

Freshwater

Freshwater would have been a limiting factor in the use made of the smaller islands. On Great I, year-round water is available in Tasman Stream and for much of the year in Baylis Stream, Castaway and Lady Fergusson Valleys and the far eastern stream. Seepages at the south east end of South West Island were probably sufficient except in the driest periods but only minor, very seasonal seepages are present on North East and West Islands. Guano contamination makes these seepages unusable at the present time and may have also in the past.

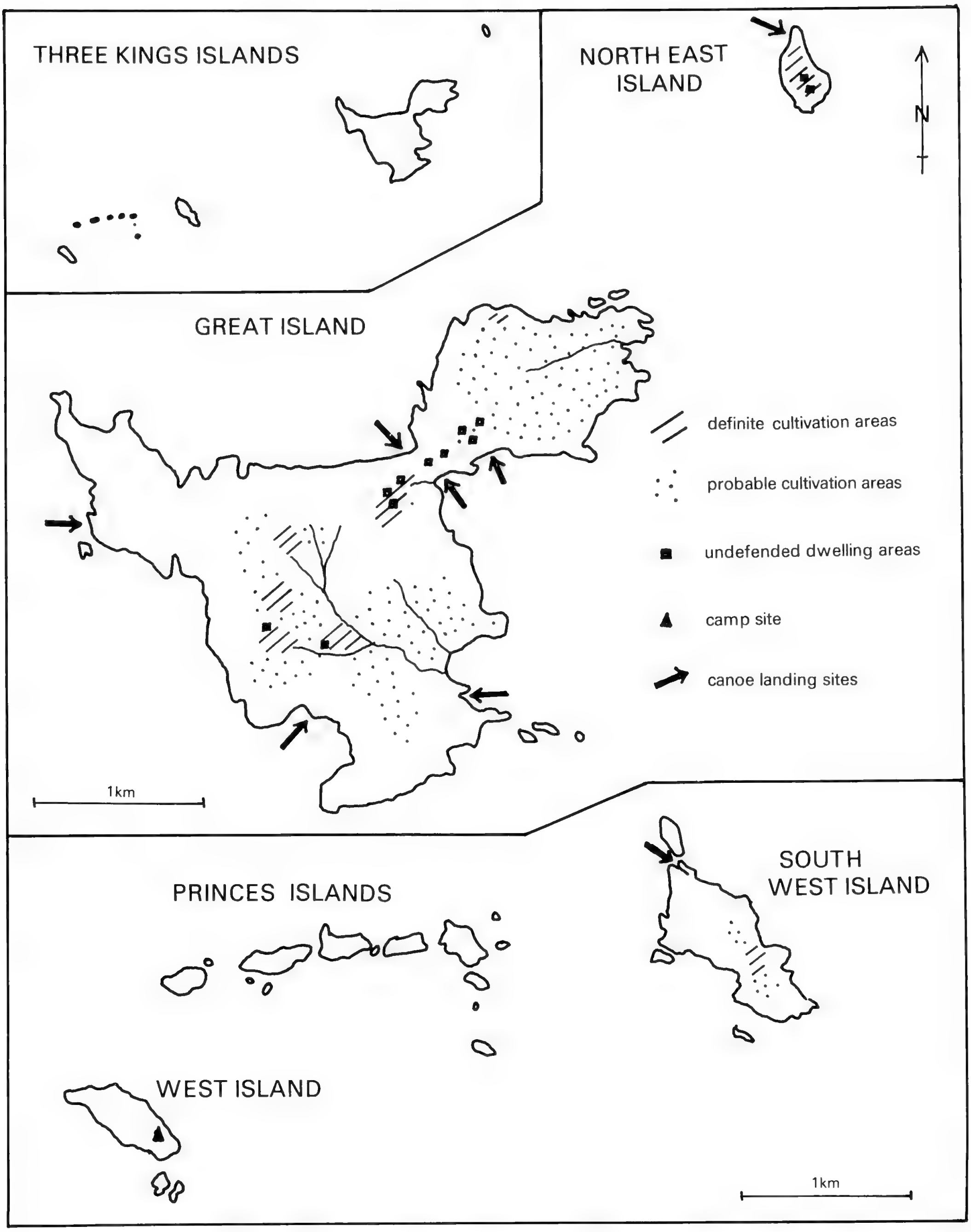

Fig.8. Map showing areas of interpreted prehistoric use on the Three Kings Is.

Cultivations

The dominant archaeological features on the Three Kings are stonework (heaps, rows and retaining walls) and elongate hillside terraces.

These are classical indications of gardening (Leach 1984). Stonework features generally occur on or near the base of steeper slopes where the ground was naturally more rocky. Stones, cleared from the surface to facilitate cultivation, were piled in heaps, over which gourds may have been grown, or used as retaining walls, to help reduce erosion of the exposed soil (Leach 1984). Stones piled into elongate rows aligned parallel to the slope (e.g. L1/11) possibly served as boundary markers between two adjacent plots. The series of parallel, shallow ditches that ascend the gentle slopes of the broad, valley-floor sites in Tasman Valley (L1/7,9) were probably also boundary markers between separate, strip-shaped, family plots (Leach 1984). In 1643, Tasman recorded (Heeres 1898) seeing "square" gardens in Tasman Valley.

The main crop cultivated by the prehistoric Maori on the Three Kings was probably kumara, which is hardy and well-suited to the fairly dry summer conditions of these hillside gardens. The group's northerly location, lack of frosts and relatively warm climate may have provided the long growing season needed for the cultivation of yam and taro, which were also brought to New Zealand with the early Polynesian immigrants. Taro was probably only grown in the wetter parts of the floors of Tasman, Baylis and Castaway Valleys, as it requires plenty of moisture. Gourd too is fairly hardy and was probably grown here to provide food in early summer (young fruits) and containers (mature fruit).

Considering the extent of archaeological evidence of cultivation it is most unusual not to find any pits for the subterranean storage of crops on these islands. On mainland New Zealand, including Northland, kumara and yam were stored over winter in subterranean storage structures to keep the temperature above 10° C and thereby prevent tissue damage (Leach 1984). Perhaps the Three Kings' climate was not sufficiently cool in winter to require subterranean storage and the open-sided storehouse or platform, typically used in tropical Polynesia may have sufficed. Alternatively it may have been warm enough to grow kumara all year round and not require its storage, although if yam were grown the tubers would have needed lifting in the winter.

Archaeological evidence for gardening activities on the Three Kings has been found on less than half the available flat or gently sloping land. Where no features are present, the land is usually free of stones and not steep enough to require terracing. Thus the absence of positive evidence of its use does not rule out the great likelihood that it was indeed cleared and cultivated. Often the prehistoric Maori strategy was to clear an area of forest, cultivate it for a few years until its fertility dropped, then move on to newly cleared land (Leach 1984). Thus, while most of the flat and gently sloping land on the islands was probably cultivated, only a portion of this would have been in use at any one time. One practice common in some parts of New Zealand was to add beach gravel, sand and charcoal to the soil to improve it for cultivation. As there are no sand or pebble beaches on the Three Kings, it seems unlikely that the rounded pebbles

that occur in the soil on some islands were added by the prehistoric Maori. Relict terrace deposits or seal gastroliths are a more probable explanation.

The distribution of potential cultivatable land together with the archaeological evidence shows that most gardening took place on Great I, especially in Tasman Valley, Castaway Valley and on the north east portion. Fraser (1929) estimated from his observations that at least 80 ha had been cultivated on Great I but this may be an underestimate. Archaeological evidence also suggests that the top of North East I and the plateau on South West I were also cultivated.

Dwellings

Within or on the edge of some of these garden areas there are clusters of several, smaller terraces, often with stone retaining walls. Excavations on similar features in Northland and Auckland (Leach 1984) suggest that these may be the sites of lean-to shelters or sleeping huts, adjacent to the gardens.

On Great I the concentration of smaller terraces, elaborate stonework and midden deposits in Castaway Valley and around the slopes about South East Bay to Lady Fergusson Valley (L1/2,3,11) suggests that this was the favoured site for dwellings, close to the good landings on either side of the saddle. As mentioned earlier, five hut sites can be positively identified on one terrace in Castaway Valley. From the finds of early European items in middens adjacent to the old castaway depot (Archey unpublished notebook, Ian Lawlor pers. comm.), it would seem that this is also the dwelling site of Tom Bowline and his family in the 1830s.

Hut sites are undoubtedly also present on North East I but are not easily distinguished from cultivation terraces.

The small cluster of terraces on West I is not located near any cultivations so may have been the site of temporary huts or lean-to shelters used by parties visiting the island, perhaps in the mutton-birding season. It is inconceivable that anyone lived permanently or even for any extended period on this small, exposed island.

Unlike most mainland areas or inshore islands, there appears to be no defended village (pa) on the Three Kings. There are no defensive earthworks and on Great I none of the naturally more defendable locations, such as hills and cliff tops, have been utilised. The closest approximation to a pa is North East I, which by its nature (Fig.2) would be difficult to assault. There is no suggestion on the island itself however, that this was its function. It would appear that the Maoris who lived on the Three Kings did not feel threatened enough to build a pa and considered the group's isolation and natural defences sufficient protection.

Food

Fish abound in the waters around the Three Kings today and fishing may have been the major source of food for the island inhabitants. This would be complemented

by cultivated crops and in season the eggs and young of seabirds (red-billed gulls, gannets, petrels and shearwaters), that nest on the islands in thousands today. Unlike some mainland areas, shellfish would have been a very minor part of the diet as there are no beaches for sand-dwelling staples such as huanga (*Austrovenus stuchburyi*), pipi (*Paphies australis*) or tuatua (*Paphies subtriangulata*). The very small amount of shell midden found attests to the occasional harvesting of a few limpets (*Cellana denticulata*) and white rock shells (*Thais orbita*) from the intertidal rocks.

Prehistoric population

The archaeology indicates that a population of Maoris lived permanently on the Three Kings for one or more periods in prehistoric times (pre 1800). Early European records and Maori traditional history suggests that this may have been for much of the seventeenth and eighteenth centuries. Without detailed excavations to provide dateable material it is impossible to determine when the prehistoric Maori first began using these islands, either as seasonal visitors or inhabitants. The actual number of people that lived permanently on these islands would have been limited by their ability to catch and grow sufficient food. It seems unlikely that the population ever greatly exceeded 100 persons and quite probably was usually considerably fewer.

Impact on the biota

In the process of preparing the land for cultivation, almost all the original coastal forest on Great, North East and South West Is would have been cleared by the pre-historic Maoris. In his journal, Tasman (Heeres 1898) wrote that in 1643 "...our people saw no trees..." and in 1772 Marion du Fresne described the islands as barren (Roth 1891). When Cheeseman (1891) visited Great I in 1889 he found it had regenerated to a mixture of short kanuka (*Kunzia ericoides*), bracken (*Pteridium aquilinum*), flax (*Phormium tenax*) and grass with only remnant forest trees on inaccessible cliffs and a few pohutukawas (*Metrosideros excelsa*) near the mouth of Tasman Stream. It is clear that the present vegetation on West and Princes Is is also regenerating and may have been largely cleared or burned in prehistoric times. Today the Three Kings Is are jealously guarded by naturalists because of the many endemic plants (at least 10 species) and small animals (landsnails, insects, spiders). Most of these are now recovering well from the enormous impact of prehistoric forest clearing, European fires and the browsing of goats (Great I only). This forest devastation and habitat destruction had resulted in many of the endemic plants and animals being reduced to very small populations. Indeed, two plant species are still only represented in the wild by a single specimen each (Wright 1983). It is logical to conclude therefore that an unknown number of additional endemic plants and animals became extinct as a result of man's activities on the Three Kings Islands.

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VEGETATION QUADRATS 1982-83 AND BROAD REGENERATION PATTERNS ON GREAT ISLAND, THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. Vegetation quadrats established in 1946 following the removal of goats from Great Island, Three Kings Group, were re-surveyed in 1982 and 1983. New plans of the quadrats are presented, and compared with earlier surveys in 1946, 1951 and 1963. For the two forested quadrats basal area and density figures are presented. A broad discussion of forest regeneration patterns on the island is given.

The three vegetation quadrats established by Turbott in 1946 (Turbott 1948) on Great Island, Three Kings Group (Fig.1) to monitor changes following the removal of goats were remapped in 1951 (Holdsworth 1951) and 1963 (Holdsworth & Baylis 1967). This paper describes them during the Offshore Islands Research Group's expeditions 12-18 December 1982 (when GTSB and AEW studied Quadrat III) and 25 November — 2 December 1983 (when EKC and GTSB mapped Quadrats I and II).

METHODS

Quadrats I & II

The quadrats were divided into smaller squares with string laid by compass and sighting, much as in the previous two surveys: 400, 2x2 m squares for Quadrat I and 225, 1x1 m squares for Quadrat II (Fig.2). The original stone cairns at each corner of the quadrats were still in place, made easier to find by the aluminium poles of 1963. Plastic boundary markers, also attached by Holdsworth & Baylis in 1963 clarified the boundaries of the quadrats. Even so, there were still minor discrepancies in matching the 1963 and 1983 boundaries.

Presence or absence of vascular plants were recorded for each small square (Figs.3,4), apart from seedlings of woody species ($<$30 cm tall and with at least one true leaf) which were recorded separately. The position of all woody plants with a diameter at breast height (dbh) $\geqslant$2.5 cm, was mapped and their diameters measured. As in previous surveys shrubs and young trees were not mapped. Instead they were recorded as present/absent in the small squares. Apart from *Pyrrosia serpens* epiphytes were absent.

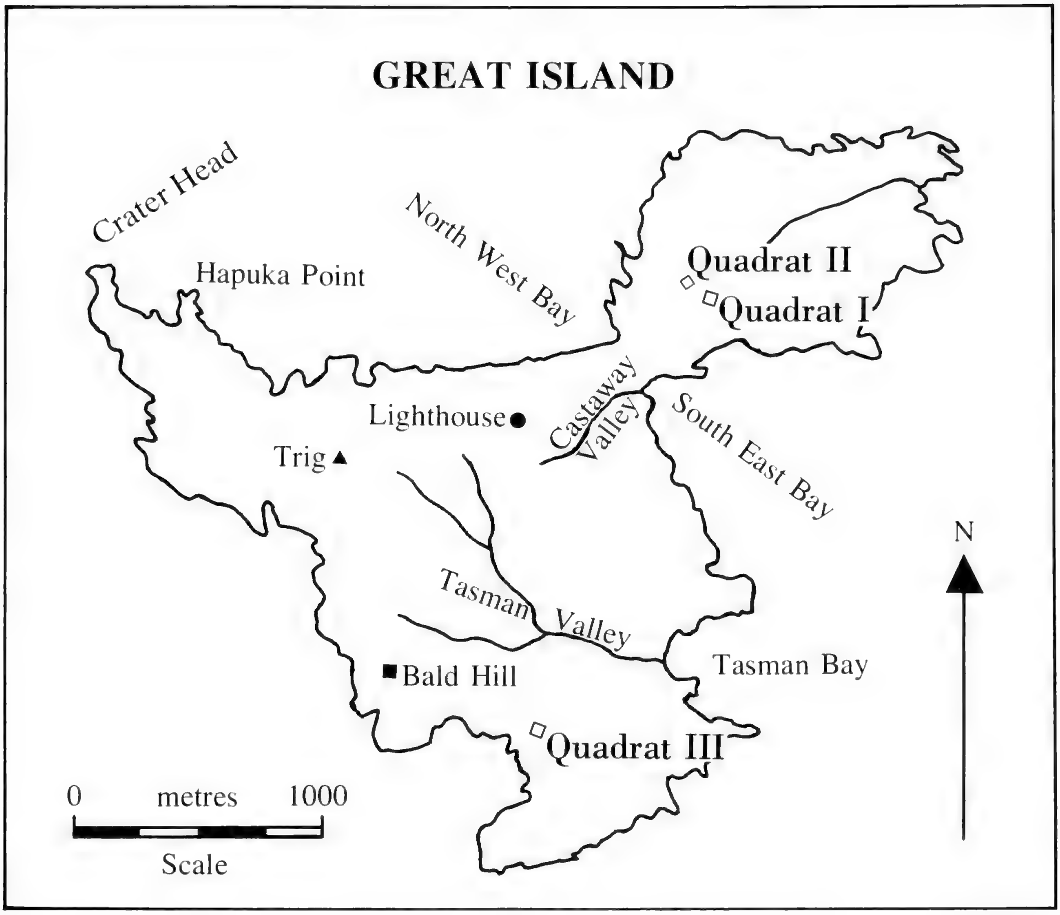

Fig. 1. Location of permanent vegetation quadrats on Great Island, Three Kings Group.

Quadrat III

By 1982, the vegetation over most of this quadrat had become so dense that the laying out of a grid square would have caused considerable damage. It was decided to mark the boundaries of the quadrat with tape. The quadrat was then divided into visually distinct areas based on height and species composition and these areas mapped. Lists were made of all species present in each area, and each species was assigned a cover value, *viz.* 1 : < 1%; 2 : 1 < 10%; 3 : 10 < 30%; 4 : > 30%. As in earlier surveys, kanuka (*Kunzea ericoides*) was divided into the apparently genetically distinct types (erect and trailing) referred to by Holdsworth & Baylis (1967).

RESULTS AND DISCUSSION

The position of a few canopy trees mapped on the previous survey did not quite correspond with our results for Quadrats I & II. The ground, which is on a gradual slope, also appears to have moved slightly as the exact dimensions of the quadrats were

Fig. 2. Stringing out Quadrat II into 1x1 m squares on 27 November 1983.

not true. For example, Quadrat I starting with the western boundary and proceeding clockwise, measured 40.0 x 40.0 x 40.1 x 39.5 m; Quadrat II starting with the north-west side, 15.0 x 15.7 x 15.2 x 15.2 m.

Quadrat I

Of the four seedlings marked in 1946, only two survive today. Both are wharangi (*Melicope ternata*) (Table 1). Their growth over 37 years has been very slow. The overall number of species present on the quadrat has slightly decreased since 1963 (Table 2).

Canopy (Fig.3). The canopy is closed and rather even at 8-12 m in height, apart from the few emergent mangeao (*Litsea calicaris*) and a rather narrow gap running east-west, situated north-east of the centre of the quadrat.

Table 1. Quadrat I. Height of the four marked seedlings[1].

Peg no.	Species	1946	1948	1951	1983 height	1983 dbh[2]
1	*Melicope ternata*	15.2[3]	86.4	144.8	500.0	6.0
2	*Melicytus ramiflorus*	2.5	40.6	—	—	—
3	*Melicope ternata*	10.2	76.2	88.9	180.0	2.0
4	*Passiflora tetrandra*	5.0	61.0	—	—	—

[1] Refer to Turbott (1948) and Holdsworth (1951).
[2] Diameter at breast height (1.4 m).
[3] cm.

Table 2. Quadrats I — III. Number of species of vascular plants per quadrat.

Quadrat	1946	1951	1963	1983
I	23	25	37	33
II	18	18	21	23
III	13	21	32	35*

* Recorded in 1982.

Mahoe (*Melicytus ramiflorus*) is the most frequent woody plant present being two and a half times more frequent than the next common species, which is kanuka (Table 3). However mahoe are relatively small-trunked contributing only 18% to the total basal area compared with 48% by kanuka (Table 4). Many of the trees are multi-stemmed: 27% of mahoe, 14% of kanuka, but by far the most frequently branched is the Three Kings' cabbage tree (*Cordyline kaspar*) (hereinafter referred to as cabbage tree) at 67%. Ten kanuka present in the canopy in 1962 have died and only five new kanuka have replaced them (Table 5). Nine mahoe died during the same period, but these have been replaced by 125 individuals. Puka (*Meryta sinclairii*) has doubled its frequency in the canopy during this 20 year period and the total number of canopy plants has doubled since 1963 (Table 3). However, there is less change in the basal area since large kanuka have been replaced with smaller and more numerous mahoe.

Coprosma macrocarpa and parapara (*Pisonia brunoniana*) have reached the canopy for the first time (Table 3). The basal areas of all the species recorded in the canopy in 1963, excluding the original canopy plants, showed small increases (Table 4). Some of the "new" cabbage trees are doubtless suckers from old plants which have died down.

Table 3. Quadrats I & II. Density[1] of canopy plants[2].

	Quadrat I				Quadrat II			
	1946	1951	1963	1983	1946	1951	1963	1983
Brachyglottis arborescens			6.3	12.5				
Coprosma macrocarpa				37.5				133.3
Cordyline kaspar	181.3	212.5	175.0	187.5	44.4	44.4	1066.6	622.2
Entelea arborescens			125.0	193.8				
Geniostoma rupestre			12.5	181.3				44.4
Kunzea ericoides	312.5	212.5	387.5	356.3	2044.2	888.8	933.2	977.8
Litsea calicaris	25.0	25.0	31.3	81.3				
Melicope ternata	31.3	31.3	56.3	131.3				
Melicytus ramiflorus	6.3	6.3	512.5	1231.3			44.4	88.9
Meryta sinclairii			93.8	193.8			400.0	311.1
Pisonia brunoniana				81.3				
Pittosporum fairchildii		6.3	6.3	68.8				
Streblus smithii		12.5	18.8	87.5			44.4	44.4
Totals	556	506	1425	2844	2089	933	2489	2222

[1] Numbers of living individual plants per hectare.
[2] Diameter at breast height ⩾2.5 cm.

Table 4. Quadrats I & II. Basal area[1] of canopy plants[2].

	Only canopy plants first recorded in 1963				Total canopy plants	
	Quadrat I		Quadrat II		Quadrat I	Quadrat II
	1963[3]	1983	1963[3]	1983	1983	1983
Brachyglottis arborescens	0.17 (3)	0.51 (4)			0.52 (1)	
Coprosma macrocarpa					0.05 (<1)	0.09 (<1)
Codyline kaspar			1.58 (38)	1.78 (18)	5.28 (12)	2.49 (6)
Entelea arborescens	0.84 (14)	0.35 (3)			1.04 (2)	
Geniostoma rupestre	0.11 (2)				0.61 (1)	0.04 (<1)
Kunzea ericoides	2.18 (37)	5.69 (43)	1.36 (33)	5.11 (52)	21.23 (48)	35.07 (86)
Litsea calicaris					4.08 (9)	
Melicope ternata	0.13 (2)	0.13 (1)			0.39 (1)	
Melicytus ramiflorus	1.68 (29)	4.72 (35)	0.35 (9)	1.47 (15)	7.84 (18)	1.47 (4)
Meryta sinclairii	0.75 (13)	1.91 (14)	0.80 (20)	1.42 (15)	2.73 (6)	1.42 (4)
Pisonia brunoniana					0.13 (<1)	
Pittosporum fairchildii					0.06 (<1)	
Streblus smithii	0.04 (<1)	0.05 (<1)		0.04 (<1)	0.19 (<1)	0.04 (<1)
Totals	5.9 (100)	13.4 (100)	4.1 (100)	9.8 (100)	44.1 (100)	40.6 (100)

[1] Area of stem across section at breast height (1.4 m) m^2 per hectare.
[2] Diameter at breast height ⩾2.5 cm.
[3] Adapted from Table 3, Holdsworth & Baylis (1967).

Table 5. Quadrats I & II. Numbers of canopy trees*[1].

	Quadrat I							Quadrat II						
	1946	1951	1963		1983			1946	1951	1963		1983		
Brachyglottis arborescens				(1)		(1)	[1]							
Coprosma macrocarpa							[5]							[3]
Cordyline kaspar	29	34	28	—	22	—	[8]	1	1	1	(23)	1	(12)	[1]
Entelea arborescens				(20)		(6)	[25]							
Geniostoma rupestre				(2)[2]			[29]							[1]
Kunzea ericoides	50	34	23	(39)	20	(32)	[5]	46	20	15[3]	(6)	15	(6)	[1]
Litsea calicaris	4	4	4	(1)	4	—	[9]							
Melicope ternata	5	5	4	(5)	1	(2)	[18]							
Melicytus ramiflorus	1	1	1	(81)	1	(72)	[125]				(1)		(2)[4]	—
Meryta sinclairii				(15)		(13)	[18]				(9)		(7)	—
Pisonia brunoniana							[13]							
Pittosporum fairchildii		1	1	—			[11]							
Streblus smithii		2	1	(2)	1	(2)	[11]				(1)		(1)	—
Totals	89	81	62	(166)	49	(128)	[278]	47	21	16	(40)	16	(28)	[6]

* Survivors of 1946 canopy not bracketed; figures in parenthesis first recorded in canopy in 1963; figures in square brackets first recorded in canopy in 1983.

1 Plants with a diameter at breast height ⩾2.5 cm.
2 Originally recorded as 3, but only 2 shown on 1963 quadrat.
3 Originally recorded as 13, but 15 shown on 1963 quadrat.
4 Originally recorded as 1, but another recorded as a different species in 1963, see Appendix 1.

Shrubs (Appendix 1). Since the quadrat was established the seven ngaio (*Myoporum laetum*) shrubs have decreased in number and by 1983 all were dead (Table 6). There have been no new species in the shrub layer but the abundance of species has changed. Because the shrubs in 1983 were only recorded as present/absent in the smaller squares, changes cannot be quantified, but general trends are evident. Mahoe (especially), mangeao and kanuka have decreased through ascending into the canopy, and there are now no kanuka shrubs. All other species have increased, especially *Coprosma macrocarpa*, parapara and hangehange (*Geniostoma rupestre*).

Lianes (Fig.3). The three liane species previously recorded are still present. On the present/absent basis in the 2x2 m squares the number of rooted plants of *Clematis paniculata* has only slightly increased, *Muehlenbeckia complexa* (erroneously recorded as *M. australis* on the 1963 Quadrat I canopy diagram, Holdsworth & Baylis 1967) shows a 35% increase and *Passiflora tetrandra* a 70% increase. Because these plants are capable of rooting at their nodes this increase is not necessarily an increase in the number of individuals.

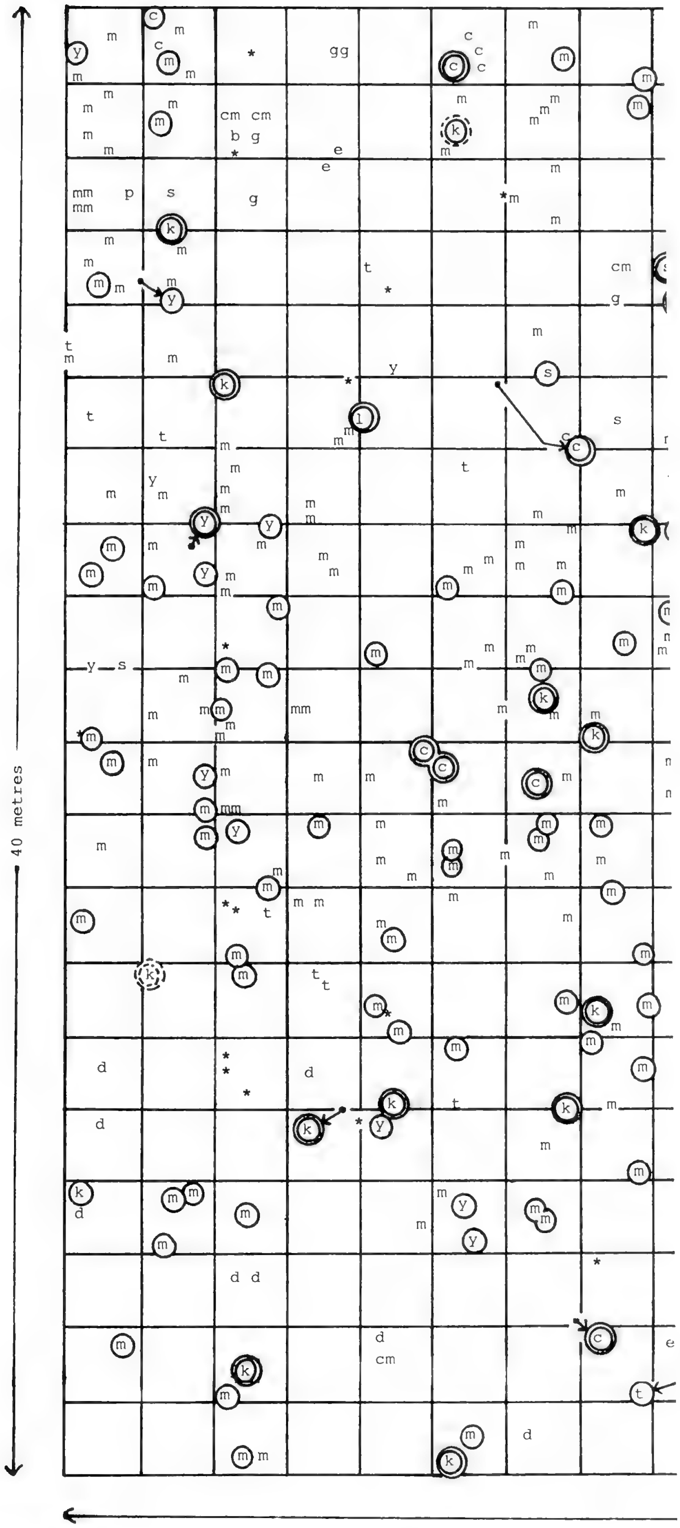

Fig. 3. Quadrat I, 1983. Plants with ≥2.5 cm dbl
since 1963. No outline indicates the plant was r
th

— also recorded in 1963.

— original canopy tree.

b. *Brachyglottis arborescens*. c. *Cordyline kasp*
arborescens. g. *Geniostoma rupestre*. k. *Kunz*
s. *Streblus smithii*. t

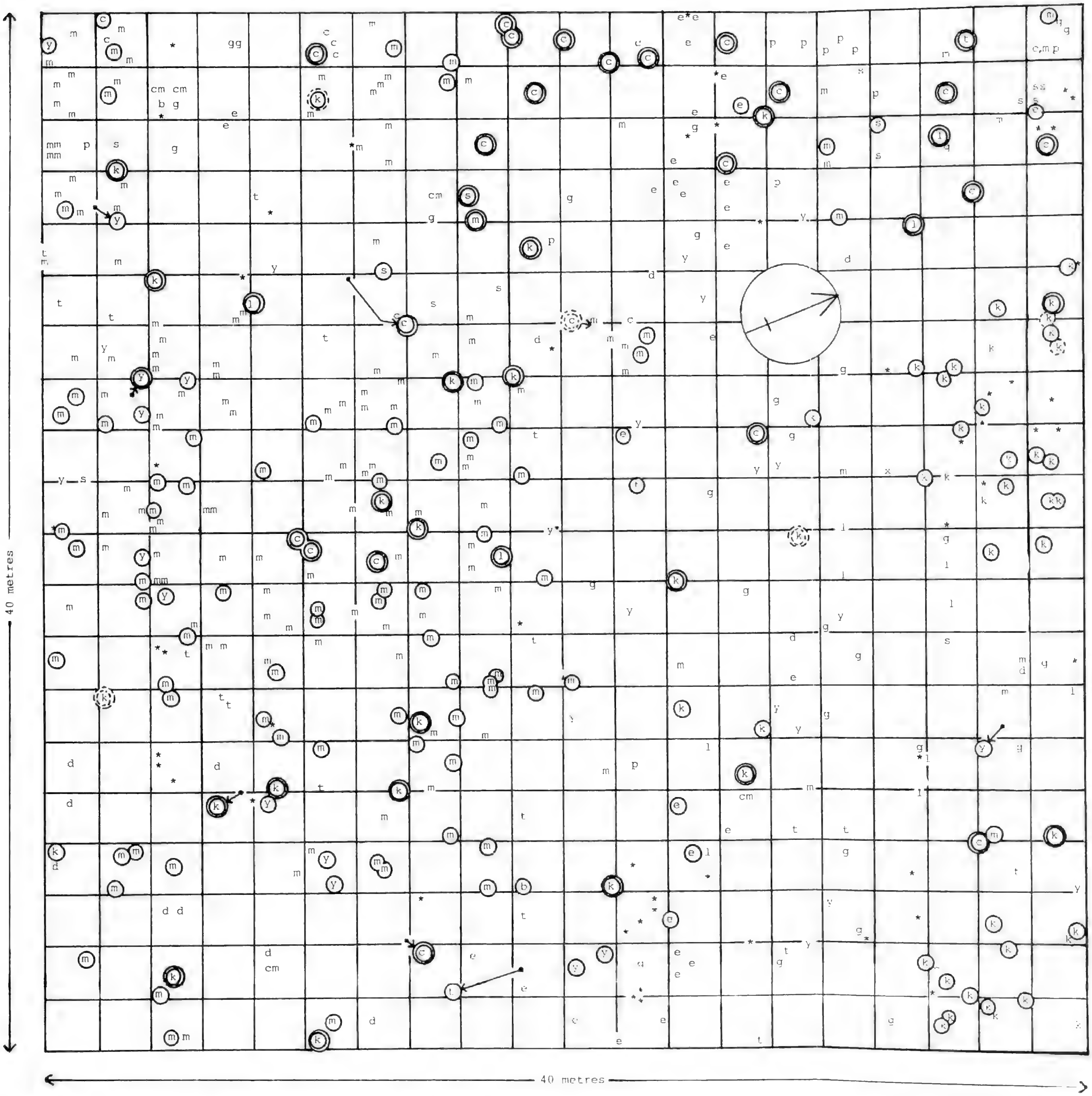

Fig. 3. Quadrat I, 1983. Plants with $\geq$2.5 cm dbh, excluding lianes. Stars indicate sites of trees that have disappeared since 1963. No outline indicates the plant was not recorded in the canopy in 1963. Arrows reconcile positions with those on the 1963 map.

— also recorded in 1963. — dead standing trees.

— original canopy tree. — wrongly shown as dead in 1963.

b. *Brachyglottis arborescens*. c. *Cordyline kaspar*. cm. *Coprosma macrocarpa*. d. *Pisonia brunoniana*. e. *Entelea arborescens*. g. *Geniostoma rupestre*. k. *Kunzea ericoides*. m. *Melicytus ramiflorus*. p. *Pittosporum fairchildii*. s. *Streblus smithii*. t. *Melicope ternata*. y. *Meryta sinclairii*.

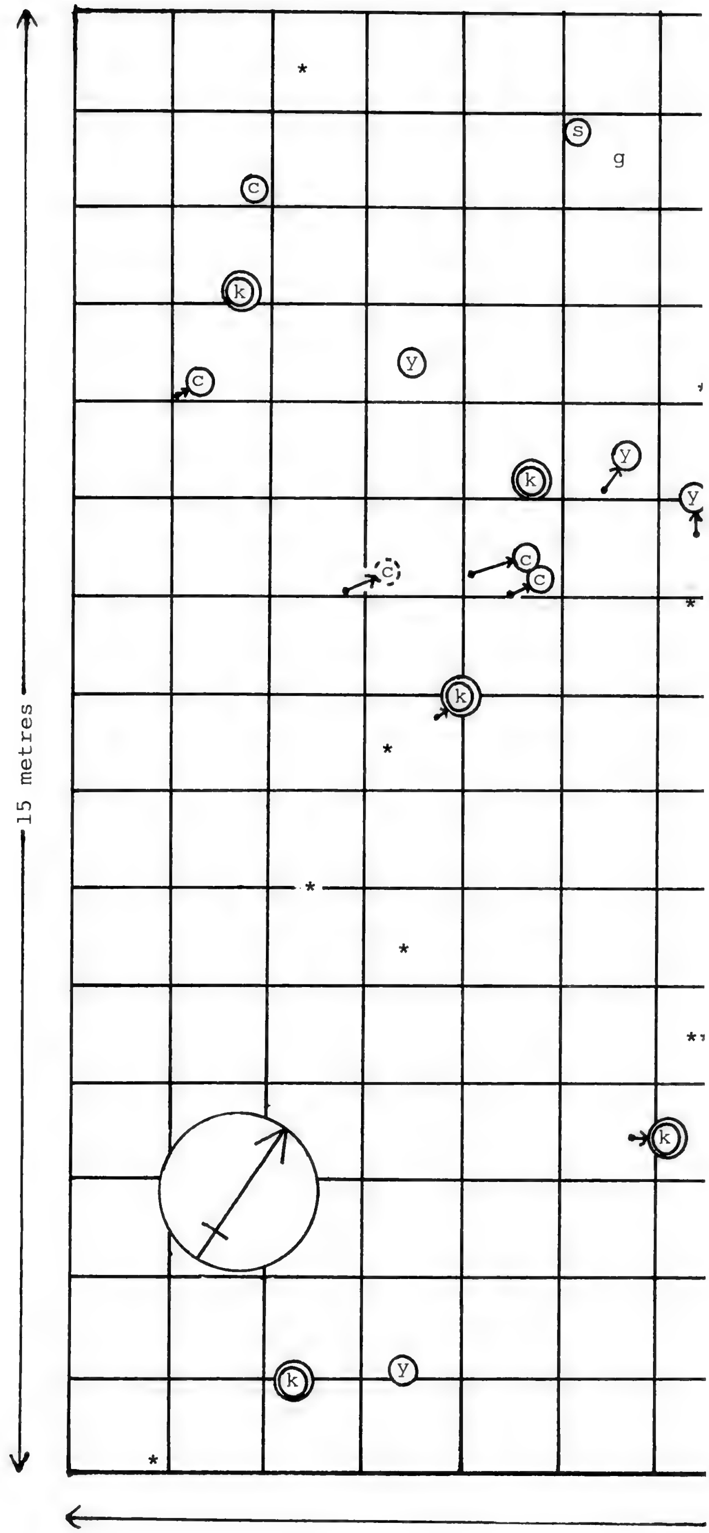

Fig. 4. Quadrat II, 1983. Plants with ≥2.5 cm
disappeared since 1963. No outline indicates the pl

○ — also recorded in 1963.

◎ — also recorded in 1951.

c. *Cordyline kaspar*. cm. *Coprosma macrocarp*
ramiflorus. s. *Stre*

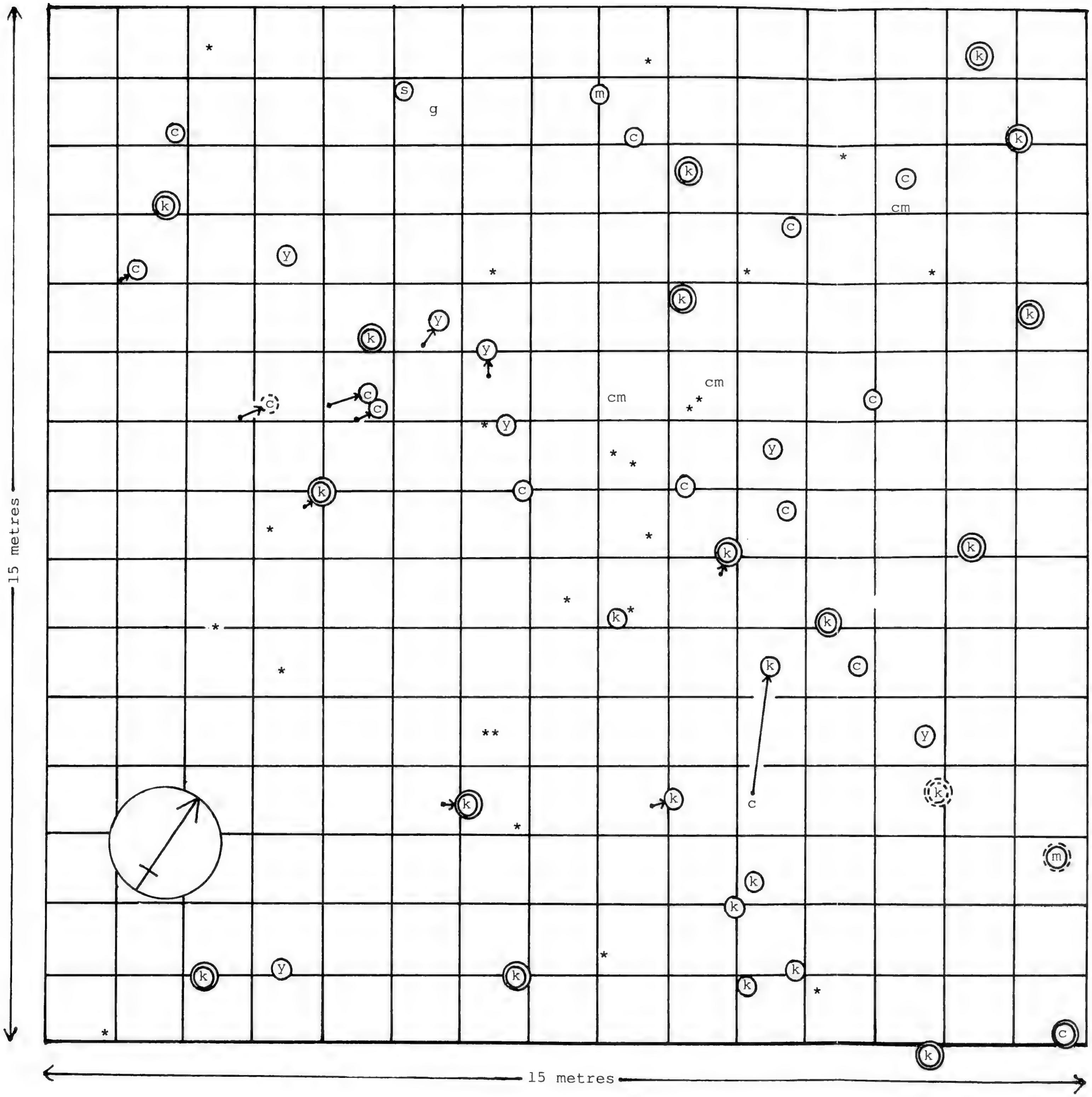

Fig. 4. Quadrat II, 1983. Plants with ⩾2.5 cm dbh, excluding lianes. Stars indicate sites of trees that have disappeared since 1963. No outline indicates the plant is new to the site. Arrows reconcile positions with those on the 1963 map.

— also recorded in 1963.

— dead standing trees.

— also recorded in 1951.

— recorded as a different species in 1963.

c. *Cordyline kaspar*. cm. *Coprosma macrocarpa*. g. *Geniostoma rupestre*. k. *Kunzea ericoides*. m. *Melicytus ramiflorus*. s. *Streblus smithii*. y. *Meryta sinclairii*.

Herbs (Appendix 1). An increase in diversity of herbs was recorded in 1963, but the number has now declined from 19 to 16 species, though four are new (Table 6). There has been a further reduction in the area covered by the sedges (*Carex* spp.) and *Pratia physaloides*. The fern *Doodia media* has slightly increased in abundance.

Quadrat II

There has been a net increase of two species since 1963 (Table 2), six gains and four losses (Table 6). Over the life of the quadrat, 17 species have come and gone (Table 6).

Canopy (Fig.4). Apart from the northern corner where there are large gaps, the canopy is rather even and closed at 8-10 m in height. The most numerous species is kanuka with cabbage tree second (Tables 3,5). Kanuka is the only species with significant basal area (Table 4). The canopy has always been dominated by kanuka, even when cabbage trees were more numerous, as cabbage trees have relatively narrow heads. Mahoe and parapara have not increased in number, unlike the situation on Quadrat I. The grand total of canopy plants has slightly decreased since 1963 (Table 3).

None of the 21 kanuka recorded in the canopy in 1963 have died and there has been one addition (Table 5). Cabbage trees on the other hand have almost halved in number during this period, but some rootstocks may remain alive. *Coprosma macrocarpa* and hangehange have now reached the canopy. The basal areas of the species recorded in the canopy for the first time in 1963 show small increases, except kanuka and mahoe which show approximately 4-fold increases (Table 4).

Shrubs (Appendix 2). The single ngaio recorded in 1951 was missing by 1963, and now the single wharangi recorded in 1946, 1951 and 1963 has also disappeared (Table 6). *Coprosma macrocarpa* is recorded on the quadrat for the first time in low numbers. Compared with 1963 figures there is little change in abundance of *Coprosma rhamnoides*, by far the most abundant shrub. Mahoe, *Streblus smithii* and parapara are present in very low numbers, as in 1963, but parapara is also represented by 20 seedlings. Cabbage trees and kanuka have decreased; mangeao, *Pittosporum fairchildii* and hangehange have increased, the latter markedly.

Lianes (Appendix 2). The two lianes recorded in 1963 are still present in low numbers. *Passiflora* covers more than twice as many squares as *Clematis*.

Herbs (Appendix 2). In Quadrat I, 53 squares (2x2 m) are bare of herbs but in Quadrat II ground cover remains dense (Fig.2) with only one empty square (1x1 m). Over the lifetime of the quadrat, 16 herb species have come and gone; five have been gained and four lost since 1963 (Table 6).

Quadrats I and II

After an initial increase in response to the cessation of goat browsing in 1946 the number of vascular plant species per quadrat has remained roughly the same since

Table 6. Quadrats I — III. Numbers of rooted plants, excluding canopy trees[1]*.

	Quadrat I				Quadrat II				Quadrat III			
Species[3]	1946	1951	1963	1983[4]	1946	1951	1963	1983[4]	1946	1951	1963	1982
Adiantum hispidulum			P†	1.8				0.9			12	P
Aira caryophyllea										P	33	P
A. praecox					P					P	2	
Arthropodium cirratum						1	P	0.4				
Asplenium oblongifolium (*A. lucidum*)			P[5]	5.8			P	1.8				P
Brachyglottis arborescens		2		0.5								
Bromus willdenowii (*B. catharticus*)			P									
Carex breviculmis										P	42	P
C. elingamita				1.0								
C. testacea	P	P	P	26.3	P	P	P	92.9	P	P	97	P
C. virgata	P	P	P	1.8	P							
Centella uniflora (*C. asiatica*)	P		P		P				P	P	39	P
Cerastium glomeratum												P
Chloris truncata											2	
Cirsium vulgare											5	
Clematis paniculata	P	P	P	2.0			P	2.2				
Conyza floribunda (*Erigeron canadensis*)		P	P			30				P	6	P
Coprosma macrocarpa				4.3				5.3(9/12)[2]				
C. repens			2									
C. rhamnoides	9	27	30	6.5	P	75	166	50.7			89	P
Cordyline kaspar		7	9	3.5		17	5	1.1(1/2)			P	
Cotula australis										P		
Davallia tasmanii						1					3	P
Deyeuxia avenoides												P
D. billardieri												P
Dianella nigra (*D. intermedia*)		P				11	P				3	
Dichelachne (*Deyeuxia*) *crinita*			P						P	P	83	P
Dichondra repens	P			0.3	P				P	P		
Doodia media	P		P	26.5	P	P	P	72.4	P	P	50	P
Echinopogon ovatus	P	P	P		P						6	

Elymus multiflorus (*Agropyron kirkii*)											32	
E. rectisetus												P
Entelea arborescens		3	8	3.5(1/14)								
Genioistoma rupestre (*G. ligustrifolium*)		3	17	17.8			1	21.8(17/48)				P
Geranium solanderi (*G. dissectum*)			P									
Gnaphalium audax												P
G. gynocephalum									P			
G. spicatum												P
G. sp. (*G.collinum*)[6]	P				P					P	71	
Gonocarpus incanus (*Haloragis procumbens*)												P
Haloragis erecta		P	P		P	17					2	
Hydrocotyle moschata												P
H. novae-zelandiae								0.4	P	P		
Hypochaeris radicata										P	96	P
Kunzea (*Leptospermum*) *ericoides*	43	73	7		P	12	7	2.2(3/5)	P	P	P	P
Litsea calicaris		52	75	6.5(5/26)		4	2	8.4(15/19)				
Leucopogon fasciculatus												P
L. (*Cyathodes*) *fraseri*											17	P
Lobelia anceps					P							P
Melicope ternata	15	51	39	5.3(1/21)	1	1	1				P	
Melicytus ramiflorus		238	210	5.5(2/22)		2		0.9(1/2)				
Meryta sinclairii		15	16	10.8(15/43)		8	3	10.7(20/24)				
Microlaena stipoides			P	0.3				2.7			1	P
Muehlenbeckia complexa[7]		*c*.5	P	13.8								
Myoporum laetum	7	5	2			1						
Oplismenus imbecillis (*O. undulatifolius*)	P	P	P	14.3	P	P		2.2	P		12	
Oxalis exilis (*O. corniculata*)	P				P				P	P		
Paspalum dilatatum												P
Passiflora (*Tetrapathaea*) *tetrandra*	P	P	P	25.8		P	P	5.3				

Table 6. Quadrats I — III continued.

	Quadrat I				Quadrat II				Quadrat III			
Species[3]	1946	1951	1963	1983[4]	1946	1951	1963	1983[4]	1946	1951	1963	1982
Peperomia urvilleana				0.8								
Phormium tenax											1	P
Phymatosorus diversifolius				0.8								
Physalis peruviana			P									
Pisonia (Hiemerliodendron) brunoniana			3	4.3(4/17)								
Pittosporum fairchildii	1	4	16	11.8(1/47)			2	15.1(29/34)				
Poa anceps							P					
P. pusilla								0.4				
Pratia (Colensoa) physaloides	P	P	P	15.8			P	1.8				
Pteris comans	P	P	P	14.5			P					
P macilenta											1	
P. tremula			P	0.8								
Pyrrosia serpens				1.5				0.4				
Rytidosperma biannulare												P
R. penicillatum												P
R. racemosum												P
R. sp. or spp. (*Danthonia semianularis*)									P	P	89	
Scirpus nodosus	P				P		P		P	P	123	P
Senecio glomeratus												P
Sicyos angulata			P	0.3								
Sonchus oleraceus										P		
Streblus (Paratrophis) smithii[8]	1	5	46	19.8(1/78)		3		5.3(11/12)				
Thelymitra longifolia											1	P
Vulpia bromoides (*V. dertonensis*)										P	31	P
Wahlenbergia gracilis					P					P	11	
Zoysia planifolia (*Zoisia matrella*)									P	P		
Species total	20	25	36	32	17	18	19	23	13	21	32	35

* In 1983 all potentially woody species of Quadrats I and II exceeded 30 cm in height except for seedlings shown in parenthesis[2].

† Species present.

1 Plants with a diameter at breast height (dbh) $\geqslant$ 2.5 cm.

2 Expressed as number of squares with seedlings only, over total number of squares for the species (dbh $<$ 2.5 cm).

3 Where different names were used in previous quadrat publications, the earlier name is given in parenthesis. Most are taxonomic changes, a few are mistakes in identity.

4 The 1983 figures are expressed as a frequency (% of squares in which the species is present) based on presence or absence in 400, 2x2m squares for Quadrat I; and 225, 1x1 m squares for Quadrat II. Note the frequencies of Quadrats I and II are not comparable because the divisions are different sizes.

5 Recorded as *A. obtusatum*, by mistake? However, there is a 1946 Turbott specimen of *A. obtusatum* (AK 22904) collected close to sea level on Great Island.

6 Specimens at AK of *G. collinum* collected in 1945/46 from forest and scrub on Great Island have been redetermined as *G. delicatum* by D.G. Drury.

7 *Muehlenbeckia australis* recorded on 1963 Quadrat I canopy diagram (Holdsworth & Baylis 1967) is *M. complexa*.

8 Suckers freely, making individuals difficult to identify.

1963 (Table 2). Although the abundance of each species varies greatly over time (Table 3), there has been no marked change in species composition. Even though kanuka is outnumbered by another species (mahoe) in the canopy of Quadrat I (Table 3) and is now failing to reproduce itself (Table 6), it will continue to be an important constituent of the canopy for some time because of its longevity of 80-150-(250) years (Burrows 1973).

The regeneration of Quadrat II is similar to Quadrat I but is many years behind, possibly because of the denser herb cover (Fig. 2) which makes it difficult for potential canopy seedlings to establish. This thicker ground cover may account for the decrease in the density of canopy plants since 1963 in Quadrat II and the marked increase during the same period for Quadrat I (Table 3). This difference is possibly because Quadrat I is more of a gully forest than the drier sited Quadrat II.

Although there are no published figures of basal area and denisty for similar vegetation to Quadrats I and II there are some records for coastal, North I, seral forests (Table 7). The Kapiti I manuka basal area figures (Esler 1967) are much lower and their corresponding density is much higher indicating an earlier seral stage than the Great I situation, i.e. abundant small stems with an absence of large stems. The same statistics for Hen I (D.J. Court 1978; A.J. Court 1985) are intermediate between Kapiti I manuka and Great I Quadrat vegetation. The single very high basal area result (83 m^2/ha) from Leigh (Ogden 1983) is consistent with what Ogden (1983) found for other kauri forests.

Quadrat III

The vegetation was divided into eight visually distinct areas which are mapped out in Fig.5. Appendix 3 lists the species present in each of these areas together with an assessment of their cover value and the height range of the vegetation within the area.

Since 1946, a total of 56 species have been recorded in the quadrat (Table 6), of which 17 were added in 1982. Three of these are notable new records in that they indicate maturation of the plant communites. The most important is mingimingi (*Leucopogon fasciculatus*) which was present in four of the eight areas mapped, albeit in low numbers. It is likely to become the second most important constituent of the future shrub layer (after *Coprosma rhamnoides*) beneath the kanuka canopy. The other two are *Asplenium oblongifolium* and hangehange. Both are present in very small numbers in only one of the eight areas in the quadrat, and may not yet be permanent constituents.

While 17 new records were made, 21 previously recorded species were not found in 1982 (Table 6). Again, three of species lost were indicative of maturation of the plant cover and should return. The species with the greatest potential was wharangi, an important plant in Quadrat I. Cabbage tree which can also be expected to form a notable part of future plant communities on this site, disappeared in the interval between 1963 and 1982. Holdsworth & Baylis (1967) noted that both these elements "may initiate a radical change in this part of the island" although they were "battered isolated specimens".

Table 7. Comparison between Great Island quadrats (I and II) and other North Island seral coastal forests, in terms of basal area and density.

Site	Method & area sampled (m^2)	Dominant species[1]	Basal Area (m^2/ha)	Density (stems/ha)	Density (no./ha)	DBH (cm)	Altitude a.s.l. (m)	Canopy height (m)
Great I	Plot 1x(15x15) &1x(40x40)	Kanuka/mahoe/ Cor kas	44.1&40.6 37.0&36.8	2853&4250 1156&1244	2222&2844 875&1020	≥2.5 ≥10	100	8-12
Kapiti I (Esler 1967)	PCQ[2] ≥40 points	Lep sco/Pse arb/ kanuka	18.4&24.6	3996&7769	—	≥10	200&350	5
		kanuka/Ole ran/ Pse arb	—	8026	—	≥2.5	230	10
		Ole ran/Hed arb/ mahoe/Pse arb	41.1	1433	—	≥10	455	8
		Dys spe/Bei taw/ Hed arb/mahoe	49.4	1779	—	≥10	183	12
Leigh (Ogden 1983)	PCQ *c*. 25 points	kanuka/Aga aus/ Cya dea/Vit luc	44,83&42	671,772 &1365	—	≥10	40	—
Hen I (D.J. Court 1978 & A.J. Court 1985)	Plot 3x(10x10)	kanuka/Myr aus kanuka/Met exc	31.5 31.5	— —	1967 2233	≥5 ≥5	140 15	7-8 14

[1] Abbrevations are the first 3 letters of generic and specific names.
[2] PCQ = point centred quarter sampling.

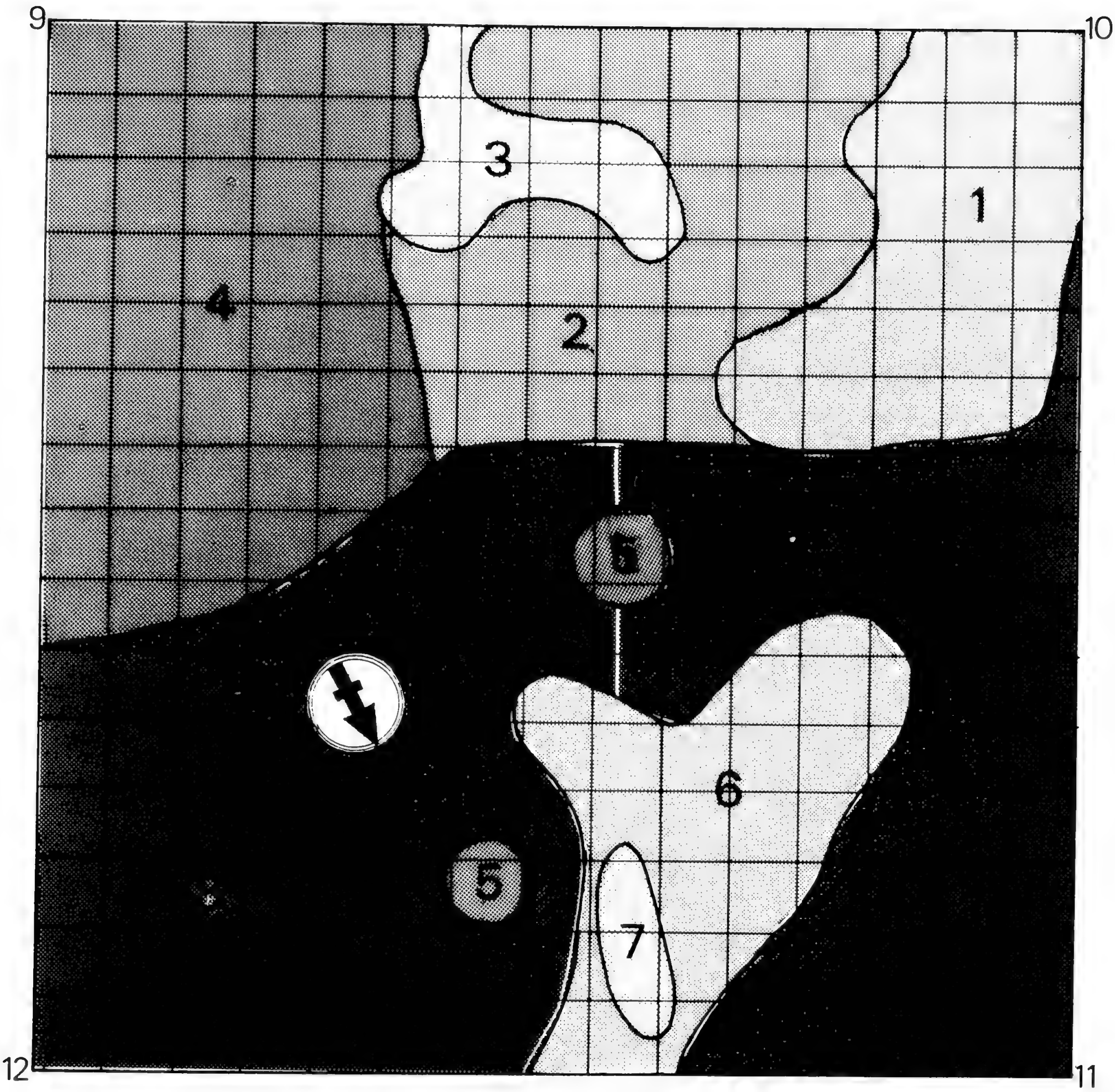

Fig. 5. Quadrat III, December 1982. Increasing density of shading corresponds with a general increase in height of the plant cover. Numbers 1-8 refer to visually different areas of the Quadrat referred to inthe text. Numbers 9-12 correspond with the standard corner numbering system of Holdsworth & Baylis (1967).

The unsuccessful attempt of these two species to establish indicates that their dispersal over the island was by 1963 beginning to probe marginal habitats.

Thirty-six years of vegetation regeneration since the removal of goats has resulted in dramatic recovery of the plant cover of the area around Quadrat III. Comparison of published photographs clearly illustrates this. Figure 14 of Turbott (1948) shows the quadrat on 28 April 1946. The area was dominated by a close-cropped sward of the

native grass *Zoysia pauciflora*. Scattered clumps of *Scirpus nodosus* and parts of two clumps of kanuka were the only contrast. Less than two years later, Baylis re-photographed the quadrat (Turbott 1948 fig.19). The removal of grazing pressure had allowed maturation of the sward, and abundant seed heads were present on the grasses. Invasion of the grassland by kanuka seedlings had begun (Holdsworth 1951).

By 1951 (Holdsworth 1951 fig.16), the *Zoysia*, though still present, had been overtopped by a sward of mixed grasses — *Dichelachne, Aira, Vulpia* and *Rytidosperma. Scirpus nodosus* provided much the same percentage cover, but had been visually overtaken by young kanuka which covered almost 25% of the plot. *Coprosma rhamnoides* was recorded for the first time.

By 1963 (Holdsworth & Baylis 1967 pl.35a), the original dominant, *Zoysia*, had completely disappeared. Kanuka occupied over 80% of the plot, with miniature *Coprosma rhamnoides* beneath it. Species diversity in the remaining grassy areas had dropped, although the total number of species recorded in the quadrat was higher than in previous surveys.

By 1982 (Fig.6) the shrub canopy was found to have diversified by the addition of *Coprosma rhamnoides* in the 0.5-1.5 m height range, and the *Coprosma* together with kanuka occupied over 95% of the quadrat. The tallest kanuka were over 2 m high. Visual inspection of the plot suggested that grasses and herbs had further declined, although the total number of species recorded shows a slight increase since 1963 (Table 2).

Comparison of Fig.7 with that of Holdsworth (1951 fig.6), shows the contrast between 1948 and 1982 quadrat vegetation from a different angle.

Table 2 indicates that species diversity, which increased markedly beteween 1946 and 1963, has begun to level out. This is to be expected as the kanuka/*Coprosma* canopy spreads and reduces the grassy areas in which the greatest species diversity occurs. Appendix 3 shows that Area 8 — the most mature kanuka/*Coprosma* stands which cover nearly 50% of the quadrat area — yielded only 8 species, while Area 1 — low grass, herb and shrubfield which occupies less than 10% of the quadrat — yielded 27 species.

As predicted by previous workers, the vegetation of this part of the island appears to be steadily developing into kanuka forest with a *Coprosma rhamnoides* shrub layer and sparse groundcover that is so common in drier areas of Great I.

FOREST REGENERATION ON GREAT ISLAND

As mentioned by Holdsworth & Baylis (1967), Quadrats I and II are not typical of the dry kanuka forests with its *Coprosma rhamnoides* understorey which is the most widespread vegetation type on the island.

Fig. 6. Quadrat III from the south-east on 14 December 1982.

Fig. 7. Quadrat III from the north-west on 14 December 1982.

Views over the canopy are still mostly of kanuka, but replacement by puka has occurred over an area of some 8 hectares upon the isthmus between North West and South East Bays (Figs.8,9) and extending north-eastwards from it to reach Quadrats I and II. Scattered crowns of puka and pohutukawa are becoming prominent on both northern and southern faces between the Lighthouse and Crater Head. On the northern face parapara is abundant, mainly as an understorey. The only completely new canopy of pohutukawa surrounds the old one below Bald Hill.

A striking change in the shrub layer since 1963 is an increase in hangehange which is dispersed by frugivorous birds (Gaze & Fitzgerald 1982; G.R. Angehr pers. comm. 1985). There were only two known plants in 1946 (Baylis 1948). Ponga (*Cyathea dealbata*), a recent immigrant from the mainland, will almost certainly prove to be a significant newcomer in the shrub layer. Single trunkless crowns were present in three separate places under kanuka north-west of Tasman Bay and one west of Quadrat I.

It is remarkable that on many sites colonised by hangehange and *Coprosma macrocarpa* canopy gaps are still repaired by kanuka (Fig.10). Sometimes there is only enough light for its seedlings after the canopy has died, as observed on Quadrat II. Yet the lighthouse clearing, made in 1969, shows how poorly kanuka competes in an area presumably by that date well-seeded by other woody species. Over most of the lighthouse clearing, kanuka has been excluded by puka, *Coprosma macrocarpa*, mahoe and even a few *Myrsine oliveri* (Fig.11).

A local study of fruit-eating birds should help explain the spread of trees and shrubs in terms of both distance and abundance. The New Zealand native bird species best able to cope with large fruit and seeds, the wood pigeon (*Hemiphaga novaeseelandiae*), is absent from the Three Kings.

The success of hangehange is outstanding, especially since there were only two known plants on the island in 1946 (Baylis 1948). Cabbage trees and mahoe seem equally pervasive, but had the advantage of a wider scatter of survivors in 1946. This is also true of *Coprosma rhamnoides*. These four species all have small ($<$ 5 mm diam) succulent fruits, the first three with numerous seeds. At the opposite end of the scale are fruits longer than 1 cm with relatively large seeds produced by karaka (*Corynocarpus laevigatus*), Three Kings titoki (*Alectryon grandis*), tawapou (*Planchonella costata*), pigeonwood (*Hedycarya arborea*), mangeao and puriri (*Vitex lucens*). These trees have seedlings only close to the parent tree, excepting puriri which has none. Accordingly, karaka though recorded by Turbott (1948) within 50 yards (45.7 m) of Quadrat I has not appeared upon it whereas *Coprosma macrocarpa* (1983), puka (1951) and hangehange (1951, 1963), all absent from the quadrats in 1946, had reached both Quadrats I and II by the years given.

Among the fruits of intermediate size a comparison of puka and *Coprosma macrocarpa* might be particularly enlightening. Puka was absent from Great I in 1946 and there were only four scattered trees of *C. macrocarpa*. However, puka was flowering on the island by 1951 (Baylis 1951). While *C. macrocarpa* seems to have reached most suitable habitats the amount of puka in the Tasman catchment is still below expectation. Baylis (1986) points out that the absence of puka from the forest

Fig. 8. Puka canopy on west-facing slope above North West Bay on 13 December 1982.

Fig. 9. View north-east along isthmus between North West and South East Bays showing puka canopy (on south-east facing slope) on 13 December 1982.

Fig. 10. Kanuka replacing kanuka. Under kanuka canopy, kanuka shrubs directly in front of figure; *Coprosma rhamnoides* in foreground; hangehange also present. Between Castaway Valley and Tasman Stream mouth on 14 December 1982.

which regenerated between the departure of the Maoris and Cheeseman's visit in 1887 (Cheeseman 1888), suggests that red-billed gulls (*Larus scopulinus*) are not as efficient in dispersing puka as has been thought, and that the present vectors are naturalised birds.

Exceptions to the fruit/seed size relationship to distribution are the non-fleshy seeds. The wind-dispersed *Brachyglottis arborescens* shows no convincing advantage; unlike puka it failed to enter the lighthouse clearing. The long sticky fruits of parapara could potentially be distributed by any larger bird happening to come into contact with them. The species has an intermediate distribution on the island. The general absence of kawakawa (*Macropiper excelsum*) which has a fleshy, small-seeded conglomerate fruit seems anomalous but Baylis (1986) points out that its habitat at the Three Kings is mature forest.

THE FUTURE

Quadrat I indicates that sites most favourable to development of forest will eventually have a stable canopy composed of long lived (coppicing) species with shade tolerant seedlings — mahoe and mangeao, the mahoe often alone because of better dispersal. The extent to which any of the larger-seeded canopy species are admixed will long reflect the centres of dispersal surviving in 1946 and their mobility which is proving to be a function of fruit size. Steep terrain, exposed ridges and knolls, landslips

Fig. 11. Regeneration on lighthouse clearing looking due east from the top of the lighthouse on 15 December 1982.

and windthrows on the island will be the sites where the diversity of light-demanding shrubs and trees will be maintained such as pohutukawa, puka, kanuka, cabbage tree, *Brachyglottis arborescens* and *Solanum aviculare*.

Because the changes presently occurring on the island are rather slow, remeasurement of the quadrats would probably not be warranted for another 20 years in view of the disturbance involved, unless the arrival of a new plant or animal species alters the present patterns. Future quantitative work should include the most widespread forest type, the dry kanuka forest of the Tasman Valley.

It will be interesting to see if wood pigeons can one day make the flight from the mainland to the Three Kings, a distance of 56 kms. The regenerating coastal forests of Northland's Te Paki Farm Park should aid such an event. Their residence on the Three Kings could alter the present regeneration patterns by aiding the distribution of the larger-fruiting plant species.

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APPENDIX 1 — See Gateleaf

APPENDIX 2 — See Gateleaf

APPENDIX 3. Quadrat III, 1982.

Cover values (1 = < 1%, 2 = 1-10%, 3 = 11-30%, 4 = > 31%) for each species present in each of the 8 areas shown in Fig.5.

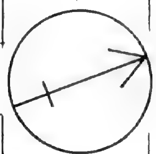
	1	2	3	4	5	6	7	8
Adiantum hispidulum						1		1
Aira caryophyllea	1		1					
Asplenium oblongifolium		1						
Carex breviculmis	1	1	1	1	1		1	
C. testacea				1		1		1
Centella uniflora	1							
Cerastium glomeratum	1							
Conyza floribunda	1			1		1		
Coprosma rhamnoides	4	2	1	4	3	4		3
Davallia tasmanii	1							
Deyeuxia billardieri				1				
D. quadriseta	1							
Dichelachne crinita			1				1	
Doodia media	1			2	1	1	1	1
Elymus rectisetus				1				
Geniostoma rupestre								1
Gnaphalium audax	1	1	1	1		1	1	
G. spicatum	1			1		1		
Gonocarpus incanus	1							
Hypochaeris radicata	1	1	1				1	
Hydrocotyle moschata	1							
Kunzea ericoides — erect	2	4		4	4	2		4
— trailing	3	2	4				4	
Leucopogon fasciculatus	1	1		1		1		
L. fraseri	4		4				1	
Lobelia anceps						1		
Microlaena stipoides	1		1					
Paspalum dilatatum	1	1	1					
Phormium tenax	1				1		1	1
Rytidosperma biannulare	1		1					
R. penicillatum	1		1					
R. racemosum	1							
Scirpus nodosus	2	1	2	1	1	1	1	1
Senecio glomeratus	1							
Thelymitra longifolia							1	
Vulpia bromoides	1		1				1	
Total number	27	10	14	12	6	11	11	8
Height range (cm)	10-70	15-90	5-40	60-130	110-160	30-70	15-30	70-200

Presence of plants with stems <2.5 cm dbh in the 2x2 m
a. *Passiflora tetrandra*. ah. *Adiantum hispidulum*. al. *Asp*
ce. *Carex elingamita*. cm. *Coprosma macrocarpa*. cp.
brunoniana. dm. *Doodia media*. dr. *Dichondra repens*.
l. *Litsea calicaris*. m. *Melicytus ramiflorus*. ms. *Micro*
pc. *Pteris comans*. pd. *Phymatosorus diversifolius*. pt. *Pte*
rhamnoides. s. *Streblus smithii*. sa. *Sicyos angulata*. t.

ct,p	ct,pt, r,y (m)	ct,p	ct,dm, p (m)	b,c, ce,cm, g,s,y	a	a,pc	dm,g, ou,pc	ct,dm, l,ou
p,s,t	ct,ou, r,p,s	a,ct,m, p,s	ct,i, ou,s	a,cm, d,ou, pc (t)	ä	pc	a,ct, dm,g,l, ou	al,ct, dm,g,l ou,p
s	cm,ct, ou,p,r, y	ct,dr, ou,p,r, s,t	cm,ct, p,pc, ou,s,t	a,s,t	c,s,t	i,p,l, pc (y)	p,ou,s	g,p
s	a	al,ct, m,ou,p, s,t	a,ce, ou,p, t,s	ce,y	g,i,p, s	a,dm, l,p (p)	pc,s	a
s,t		a,g,ou, t	p,s,y	ce,g, p,s,t	s	a,pc,s	s,t	a,s
a	a,pc, s	a		pc,t	p			t
dm	pc		t	al	al,d		s	a,s
dm,s	a	a	a	pc		t		
al,dm	m	a,pc	g,m					p
al,y	a,c		a,i					
a,pc	i	a	a	a		a	m,s	
	a	a	a	a	a,i	pc		cm,s (l)
a	a	a	a	a	a,s	pc	dm,s	
a		a,al			a,i	a		cm,pc
s		a	a		i	s		a,dm,t
m,s	ct,d,y	a,ct,m			ct	(y)		a,cm
	ah,dm, t	dm	ct,dm		l	a	al (y)	a,y (e)
t		dm	ct,dm	g,y	g	a,l (y)	a	cp,e, pc (l),(y)
a		d,s	(d)	a,cm, dm,g, s	g	a,l	a	cp,y
	al,d	a,t,y				ct,e,y	e,s (y)	a,e

APPENDIX I. Quadrat I, 1983.

Presence of plants with stems <2.5 cm dbh in the 2x2 m squares. Symbols in brackets are potentially woody plants <30 cm tall. a. *Passiflora tetrandra*. ah. *Adiantum hispidulum*. al. *Asplenium oblongifolium*. b. *Brachyglottis arborescens*. c. *Cordyline kaspar*. ce. *Carex elinganita*. cm. *Coprosma macrocarpa*. cp. *Pratia physaloides*. ct. *Carex testacea*. cv. *Carex virgata*. d. *Pisonia brunoniana*. dm. *Doodia media*. dr. *Dichondra repens*. e. *Entelea arborescens*. g. *Geniostoma rupestre*. i. *Clematis paniculata*. l. *Litsea calicaris*. m. *Melicytus ramiflorus*. ms. *Microlaena stipoides*. ou. *Oplismenus imbecillis*. p. *Pittosporum fairchildii*. pc. *Pteris comans*. pd. *Phymatosorus diversifolius*. pt. *Pteris tremula*. pu. *Peperomia urvilleana*. py. *Pyrrosia serpens*. r. *Coprosma rhamnoides*. s. *Streblus smithii*. sa. *Sicyos angulata*. t. *Melicope ternata*. ug. *Muehlenbeckia complexa*. y. *Meryta sinclairii*.

ct,p	ct,pt, r,y (m)	ct,p	ct,dm, p (m)	b,c, ce,cm, g,s,y	a	a,pc	dm,g, ou,pc	ct,dm, l,ou	cm,ct, dm,g, ou,p	cp,dm	cp,dm e,ou	a,c, cm,cp	pc,y (l)	ct,dm, ou,pd	al,g, py,r	cm,ct, g,p, pd,r	pd,py, y	py	py
p,s,t	ct,ou, r,p,s	a,ct,m, p,s	ct,i, ou,s	a,cm, d,ou, pc (t)	a	pc	a,ct, dm,g,l, ou	al,ct, dm,g,l, ou,p	cp,dm, ou,p,s	cp,dm, g,p	a,cp, dm,e (l)	cp,dm s	c,cp, g,pc	ct,d, cm,ou	g,p		ou,py	py	ct,y
s	cm,ct, ou,p,r, y	ct,dr, ou,p,r, s,t	cm,ct, p,pc, ou,s,t	a,s,t	c,s,t	i,p,l, pc (y)	p,ou,s	g,p	dm,s	c,cp, dm,s (y)	a,cp, dm,pc	dm	m	cp,ct, g,ou, pt	c,dm, s		al,s		a,cp, p
s	a	al,ct, m,ou,p, s,t	a,ce, ou,p, t,s	ce,y	g,i,p, s	a,dm, l,p (p)	pc,s	a	s	cp,dm, s	dm,g	dm	g,y	g,pc,s	ah,c, cm,g, p,y	ct,dm, p,pc,s (y)	ct,dm, p,ug	ct,ug	a,m,p, y
s,t		a,g,ou, t	p,s,y	ce,g, p,s,t	s	a,pc,s	s,t	a,s	s	dm,s, y	ah,d, dm,p, s	dm	dm,g, pc,s, y	g,s,y	dm,pc (y)	p	a,pc, ug	ct,p	a,ct
a	a,pc, s	a		pc,t	p			t	s	c,p	c,q	g,m	cp,g, m,ug	g,pc, y	al,cm, ct,pc, ug	cm,dm, m,pc, ug,y	a,ct, g,ug, y	a,ct, pc	cv,g, p
dm	pc		t	al	al,d		s	a,s	s	dm,m		m	ct,dm, e,g,s	a,cm, ct,dm, g,pc,ug	ct,d, dm,ou	a,ou, ug	ct,g, ou,ug	ct,g, r,s,ug	q,ou
dm,s	a	a	a	pc		t				dm	m	a,al, ug	cp,dm, ou,ug	dm,ug	dm,g, ou,ug	ct,r, ug	ct,p, r,ug	ct,g, r,ug	a,c,ct, g,l,ou, r
al,dm	m	a,pc	g,m					p	dm,pc, y	ct,dm, pc	a,al, s	a,d, dm,ug	a,pc, ug	al,dm	cp,ct, dm,ou	ct,dm, r,ug,g	ct,dm, g,ms, ou,r	ct,g, r,ug	ct,dm, ou,p, ug
al,y	a,c		a,i							a,dm, m	s	ug	cp,ct, dm,cv, ug	al,cp, dm,ou, ug	ct,dm, l,pc,s ou (d)	ct,dm, g (y)	a,ct, r,ug	a,ct, ug	a,ct, l,ug
a,pc	i	a	a	a		a	m,s			a	dm	dm,ug	ct,cv, ou,ug	al,ct, dm,r, ou,ug	ct,s, ug	ct,dm	ct,ug	ct,dm r,ug	ct,g
	a	a	a	a	a,i	pc		cm,s (l)	ct	dm	dm,ug	a,dm, g,ug	ah,cp, ct,ug	cp (d)(s)	c,dm, p,pc s	ct,s	ct,dm, g	a,ct, cp,i	cp,ct, g,l,pc
a	a	a	a	a	a,s	pc	dm,s		ah	a,s	ct,e, q,pc, s,y	cp,ct, dm,ou, cv,ug	ah,al, ct,dm,e m,ou,ug	cp,ct, dm,ou, p (d)	c,dm m,p,s	cp,ct, s,ug	cv,ug, y	a,pc, ug	cp,l
a		a,al			a,i	a		cm,pc		ou,pc	ct,e, g,ou, pc (y)	cp,cv, e,g,ug (y)	a,ct, dm,sa, ou (y)	cp,ct, dm,ou, ug	c,dm m,ug	cp,pc	cp,m, p,s	cp,pc	cp
s		a	a		i	s		a,dm,t	ct (l)(y)	a,pc	cp,ct, dm,ou, s	cp,ct, dm,ou, ug	a,ct, dm,ou, ug	cp,ct, ug	ct,dm, pu,s	dm,s, ug	cm	cp,pc	c,dm, l,s
m,s	ct,d,y	a,ct,m			ct	(y)		a,cm	al,b,g	al,dm, p	al,ct, g,ou, pc,s,y	ct,g, l,ou, pc,s	ah,cp, ct	a,al, ct,g, ug	i,ou	cp,dm pc,ug	dm,g,l	cp,dm	cp,dm, g,s
	ah,dm, t	dm	ct,dm		l	a	al (y)	a,y (e)	a,d,ou	a,ou	ct,g, ou,pc	a,cp, ct,ug	a,cp, ct,ou, s	cp,ct, d,g, pc,ug	dm,pc	cp,pc, pu	ou,pu	a,cp, ct,dm ou,r	cp,ct, dm,g
t		dm	ct,dm	g,y	g	a,l (y)	a	cp,e, pc (l)(y)	e,ou	al,ct, g,pc, ou	a,ou	cp,ct, pc,pt (y)	cp,pc, ug	a,cm, cp,g	a,cp	a,cp	ct,g, p	a,ct, dm,r	cp,ct, dm,r
a		d,s	(d)	a,cm, dm,g, s	g	a,l	a	cp,y	cp,d	a,cp, t	dm,pc	g	a,cp	a,cp	cp,cv, dm,g	cp,dm, p,r	ct,dm, g,r	ct,dm, g,r	a,ct, dm,r
	al,d	a,t,y				ct,e,y	e,s (y)	a,e	cp,ct, c,e		dm,pc			cp,pc	dm,g, l,p,s	cp,ct, dm,l,s	a,ct,r	ct,dm, g,r	ct,g, l,r

APPENDI

Presence of plants with no stems ≥2.5 cm dbh in the 1x1 m
a. *Passiflora tetrandra*. ac. *Arthropodium cirratum*. ah. *Ac*
cm. *Coprosma macrocarpa*. cp. *Pratia physaloides*.
h. *Hydrocotyle novae-zelandiae*. i. *Clematis paniculata*
ms. *Microlaena stipoides*. ou. *Oplismenus imbecillis*. p. *Pi*
rhamnoides. s. *Stre*

ct,dm, y	ct,dm r	ct,dm, g,r (r)	ct,dm (r)	ct,dm, r (p)	a,ct (r)	ct,r
ct,dm,r	ct,dm (p),(s)	ct,dm,r	ct,dm,r	ct,dm	ct,dm (g)	ct,r (p)
ct,dm,r, s	ct,dm	ct,dm	ct,dm (cm)	ct,dm,g	ct,dm (p)	ct,dm,r (p)
ct,dm,r	dm	ct,dm,r	ct,dm,g	ct,dm,i (r)	ct,l,r	ct,dm
ct,dm, ou,r (y)	ct,dm	a,ct,dm (l)	ct,dm,g i (p)	ct,dm (r)	cm,ct	ct,g (g),(p)
dm,r (l),(r)	dm (y)	ct,dm	ct,dm,r	ct,dm,i	ct,dm (s)	ct,r (g)
ct,dm, ou (l),(y)	dm,g	ct	ct (g)	ct (p)	ct,dm,g (cm)	ct,dm
ct,dm,g (r)	ct,dm,g (y)	ct,dm (r),(l), (p),(y)	ct (p)	ct,dm	ct (g),(r)	r (g)
ct,dm,g	ct,dm (r)	ct,dm, i,ou (c),(y)		ct,dm,g (r)	ct,g,r	ct,dm
ct,dm,r	ct,dm	ct,dm	ct,dm (g),(r), (y)	ct,dm	ct,dm, ms,r	ct,dm,r (r)
ct,dm,r	ct,dm, ps	a,ct,dm	ct,dm (g)	ct,dm (l)	ct,dm (p),(r)	ct,r
ct,dm,r (r)	ct,dm,g	ct,dm (r)	ct,dm,r (m),(r,)	a,ct,dm, (cm),(l), (r),(y)	ct,dm (g)	r (r)
ct,dm	ct,dm	ct,dm (l),(r)	ct,dm	a,ct (g),(r)	ct	ct
a,ct,dm	a,ct,dm, g,r	ct,dm	ct,dm	ct (y)	ct,g (s)	ct,r (g)
ah,ct, dm,g,p, y	ct,dm,r (r)	ct,dm,i, p	ct,dm (p),(r), (s)	ct,cp,g	ct,g,r (r)	ct,r (r),(s)

APPENDIX 2. Quadrat II, 1983.

Presence of plants with no stems ≥2.5 cm dbh in the 1x1 m squares. Symbols in brackets are potentially woody plants <30 cm tall. a. *Passiflora tetrandra*. ac. *Arthropodium cirratum*. ah. *Adiantum hispidulum*. al. *Asplenium oblongifolium*. c. *Cordyline kaspar*. cm. *Coprosma macrocarpa*. cp. *Pratia physaloides*. ct. *Carex testacea*. dm. *Doodia media*. g. *Geniostoma rupestre*. h. *Hydrocotyle novae-zelandiae*. i. *Clematis paniculata*. k. *Kunzea ericoides*. l. *Litsea calicaris*. m. *Melicytus ramiflorus*. ms. *Microlaena stipoides*. ou. *Oplismenus imbecillis*. p. *Pittosporum fairchildii*. ps. *Poa pusilla*. py. *Pyrrosia serpens*. r. *Coprosma rhamnoides*. s. *Streblus smithii*. y. *Meryta sinclairii*.

ct,dm, y	ct,dm r	ct,dm, g,r (r)	ct,dm (r)	ct,dm, r (p)	a,ct (r)	ct,r	ct,m,p, r (r)	c,ct,dm, g	ct,dm,g, r,(g), (r),(y)	ct,dm,g (p),(y)	ct,dm, h,ms,r (g)	ct,dm,g, k,py,r	ct,dm,r	ct,dm,g, r , (k)
ct,dm,r	ct,dm (p),(s)	ct,dm,r	ct,dm,r	ct,dm	ct,dm (g)	ct,r (p)	ct,dm,r (p)	ct,dm,g, r (g)	ct,dm (g),(r)	ct,r	ct	ct,dm,r (l)	ct,dm,r	ct,dm,r, y (r)
ct,dm,r, s	ct,dm	ct,dm	ct,dm (cm)	ct,dm,g	ct,dm (p)	ct,dm,r (p)	ct,dm,r, y (r)	ct,dm,r (g)	ct,r	ct,r (p)	ct,dm, ms,r (l)	ct	ct,dm,r (l)	ct,dm, ms,r (k)
ct,dm,r	dm	ct,dm,r	ct,dm,g	ct,dm,i (r)	ct,l,r	ct,dm	ct,dm	ct,dm,r (p),(r)	ct,dm (g)	a,ct,g (g)	al,ct, dm,r	ct,dm,r (p)	ct,dm,k	ct,dm, ms,r
ct,dm, ou,r (y)	ct,dm	a,ct,dm (l)	ct,dm,g i (p)	ct,dm (r)	cm,ct	ct,g (g),(p)	cm,ct, dm (cm),(r)	cm,ct, dm,r (l)	ct,dm, g,r	ct,dm,r	ct,dm,r	ct,dm,r (r)	a,al, ct,dm, r,(k)	ct,r (g)
dm,r (l),(r)	dm (y)	ct,dm	ct,dm,r	ct,dm,i	ct,dm (s)	ct,r (g)	ct,r (r)	ct,dm,g, ms	ct,dm,r (y)	a,ct (cm),(p)	ct,dm,r	ct,dm	ct,dm,r (r)	ct,r (r)
ct,dm, ou (l),(y)	dm,g	ct	ct (g)	ct (p)	ct,dm,g (cm)	ct,dm	ct,g,l	ct,dm,r (r)	ct,dm (r)	ct,dm (r)	ct,g	ct,r	ct,dm,p (p)	ct,r (g)
ct,dm,g (r)	ct,dm,g (y)	ct,dm (r),(l), (p),(y)	ct (p)	ct,dm	ct (g),(r)	r (g)		ct (g),(r)	ct,dm, ou (l)	ct,dm, ou,r (s)	cp,ct, dm,g,r (r)	ct,dm,r	ct,dm,r	ct,r (l),(r)
ct,dm,g	ct,dm (r)	ct,dm, i,ou (c),(y)		ct,dm,g (r)	ct,g,r	ct,dm	ct,g (r)	ct (r)	a (p)	dm (l),(y)	ct,dm	ct,dm,r (p)	ct,dm (p)	a,ct,dm, l
ct,dm,r	ct,dm	ct,dm	ct,dm (g),(r), (y)	ct,dm	ct,dm, ms,r	ct,dm,r (r)	ct,dm	ct (r)	dm (r)	ct (r)	dm (p)	ct,dm (y)	ct,dm (p)	cp,ct, dm,l (r)
ct,dm,r	ct,dm, ps	a,ct,dm	ct,dm (g)	ct,dm (l)	ct,dm (p),(r)	ct,r	ct,dm (g),(r)	ct,dm (r)	ct,dm	ct,dm	dm	dm (s)	ct,dm (p),(r) (y)	cp,ct, dm (s)
ct,dm,r (r)	ct,dm,g	ct,dm (r)	ct,dm,r (m),(r,)	a,ct,dm, (cm),(l), (r),(y)	ct,dm (g)	r (r)	ct,dm (r)	ct,dm (r)	ct	al,ct	dm (r)	ct,dm (cm)	ct,dm (s),(y)	ct,dm (p)
ct,dm	ct,dm	ct,dm (l),(r)	ct,dm	a,ct (g),(r)	ct	ct	ct (r)	ac,ct, dm	ct,dm (cm)	ct	ct	ct,dm (cm),(p)	ct,dm (p)	dm
a,ct,dm	a,ct,dm, g,r	ct,dm	ct,dm	ct (y)	ct,g (s)	ct,r (g)	ct,r (r)	ct	ct (r)	ct,dm	ct,dm	ct (p),(s)	ah,ct, dm (p),(y)	ct (y)
ah,ct, dm,g,p, y	ct,dm,r (r)	ct,dm,i, p	ct,dm (p),(r), (s)	ct,cp,g	ct,g,r (r)	ct,r (r),(s)	ct,r (r)	ct,r (r)	ct,dm (y)	ct,dm (cm),(g)	ct,dm (cm),(p)	ct (p),(y)	al,cm, ct (l),(s)	ct,dm (p),(y)

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A PRELIMINARY LIST OF MOSSES FROM THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. A preliminary list of 36 mosses from the Three Kings Islands is provided, based mainly on collections held in the herbarium of the Auckland Institute and Museum. The species recorded are all known members of northern New Zealand coastal communities. Comparison with moss floras of other northern offshore islands indicates that further bryological exploration of the Three Kings would be expected to reveal a much richer moss flora than is at present recorded.

Although no bryologist has yet visited the Three Kings Islands collections of mosses have been made there by a number of scientists. A few of these specimens have become the basis of published records, the most substantial being six species of moss which were recorded as substrates in a zoological study of Tardigrada (Horning *et al* 1978). Three species of terrestrial moss were included by Turbott (1948) in his account of vegetation quadrats established on Great Island. Most specimens, however, remain in herbaria as unpublished records.

In this paper an attempt is made to gather together information from the existing Three Kings moss collections. Retrieval of specimens I believe to be complete, as at September 1985, from the herbarium of the Auckland Institute and Museum (AK), with 78 packets of Three Kings mosses, and from the herbarium of the Department of Botany, University of Auckland (AKU), with 19 packets. In addition, some specimens, a number of which are duplicates of the AK holdings, have been located in the herbarium of Botany Division of DSIR (CHR), 19 packets, and of the National Museum of New Zealand (WELT), 2 packets. The collectors of these specimens, with dates of collection given in brackets, are: G.T.S. Baylis (December 1945, January 1951); E.G. Turbott (April-May 1946); M. Holdsworth (January 1951); G.W. Ramsay (November 1970); E.K. Cameron (November-December 1983); B.W. Hayward (November-December 1983) and A.E. Wright (November-December 1983)

For each species listed, records are given for individual islands within the Three Kings Group, together with the total number of collections examined by me. The specimen number of a selected voucher is given, as well as a summary of the habitat data given by collectors. Where the record is believed to be the northernmost for the species in the New Zealand Botanical Region this is indicated.

Annotated List Of Mosses Of The Three Kings Islands

Achrophyllum dentatum (Hook. f. & Wils.) Vitt & Crosby
syn. Pterygophyllum dentatum (Hook. f. & Wils.) Mitt.
Great I; 2 collections; AK 26690; Tasman Stream.

Bryum billardieri Schwaegr. var. *platyloma* Mohamed
syn. B. truncorum Brid.
Great I; 5 collections; AK 22001; under kanuka in Tasman Valley and on soil in Castaway Valley; northernmost record.

Bryum campylothecium Tayl.
Great I, North East I, West I; 4 collections; AKU 67902; terrestrial on rocks; northernmost record.

Bryum dichotomum Hedw.
Great I, South West I; 2 collections; AKU 67891; terrestrial in more or less exposed sites.

Camptochaete pulvinata (Hook. f. & Wils.) Jaeg.
Great I; 2 collections; AK 26706; Castaway Stream; northernmost record.

Campylopus bicolor (C. Muell.) Wils.
Great I; 1 collection, verified by J.-P. Frahm; AK 22644; northernmost record.

Campylopus clavatus (R. Br.) Wils.
Great I; 1 collection; CHR 164575; on clay slope at edge of pohutukawa forest remnant.

Campylopus introflexus (Hedw.) Brid.
Great I; 5 + ?2 collections; AK22000; on rocks, in clearing; recorded also by Turbott (1948).

Campylopus pyriformis (K.F. Schultz) Brid.
syn. C. torquatus Mitt.
Great I; 1 collection; CHR 406275; among kanuka and *Coprosma rhamnoides.*

Dicranella clathratum Hook. f. & Wils.
Great I; 1 collection; AK 169408; with *Fissidens asplenioides* Tasman Valley Stream; northernmost record.

Distichophyllum pulchellum (Hampe) Mitt.
Great I; 6 collections; AK 26699; Castaway and Tasman Valley Streams; northernmost record.

Eriopus cristatus (Hedw.) Brid.
Great I; 2 collections; AKU 67930; on rocky stream bank; northernmost record.

Fissidens asplenioides Hedw.
Great I; 1 collection; AK 169407; with *Dicranella clathratum*, Tasman Valley Stream.

Fissidens leptocladus C. Muell. & Rodw.
Great I; 1 collection; AK 26692; Tasman Valley Stream.

Homalia pulchella Hook. f. & Wils.
Great I; 2 collections; AK 170070; with *Racopilum strumiferum*, Tasman Stream; northernmost record.

Hypnodendron spininervium (Hook.) Jaeg.
Great I; 8 + ?1 collections; AK 168765; on rocky bank, margin of Tasman Valley Stream; northernmost record.

Hypnum chrysogaster C. Muell.
Great I; 1 collection; AK 26732; on earth, Tasman Valley; northernmost record.

Hypnum cupressiforme Hedw.
Great I; 5 collections; AKU 67928; terrestrial, under low kanuka, and on cliff by the *Pennantia baylisiana*; northernmost record.

Isopterygium cf. *minutirameum* (C. Muell.) Jaeg.
Great I; 2 collections; AK 26694, verified by Z. Iwatsuki; Castaway Stream, and among kanuka and *Coprosma rhamnoides* in north-east area of the island.

Leptodontium interruptum (Mitt.) Broth.
Great I; 7 collections; AK 22646; on earth and rocks, among stunted kanuka; recorded also by Turbott (1948); northernmost record.

Macromitrium gracile (Hook.) Schwaegr.
Great I; 1 collection; personal herbarium J.K. Bartlett, in AK; epiphytic on the fern *Davallia tasmanii*; this specimen is the basis of the record by Vitt (1983); northernmost record.

Macromitrium brevicaule (Besch.) Broth.
syn. M. wattsii Broth.
syn. M. subfragile Dix. & Sainsb.
Great Island; 2 collections; AKU 67908; epiphytic on *Cordyline kaspar*; recorded also by Vitt (1983); northernmost record.

Philonotis tenuis (Tayl.) Reichdt.
West I; 3 collections; AKU 67901 propaguliferous form; rock crevice in seepage.

Pohlia nutans (Hedw.) Lindb.
Great I; 1 collection; AK 22647; northernmost record.

Ptychomnion aciculare (Brid.) Mitt.
Great I; 6 collections; AK 26688; terrestrial under kanuka, Summit Ridge and upper Tasman Valley; northernmost record.

Racopilum convolutaceum (C. Muell.) Reichdt.
syn. Rhacopilum strumiferum C. Muell.
Great I, South West I; 6 collections; AKU 67900; Tasman Stream, and on steep bank in the open on South West Island.

Rhynchostegiella muriculata (Hook. f. & Wils.) Broth.
syn. Eurhynchium muriculatum (Hook. f. & Wils.) Jaeg.
North East I, South West I; 2 collections; AKU 67898; on rotten logs in forest; northernmost record.

Rhynchostegium laxatum (Mitt.) Par.
Great I; 1 + ?2 collections; AKU 67923; terrestrial, on rock under kanuka; northernmost record.

Rhynchostegium tenuifolium (Hedw.) Reichdt.
Great I, North East I, South West I; 4 + ?3 collections; AK 168746; terrestrial, under low kanuka.

Sematophyllum amoenum (Hedw.) Mitt.
Great I, North East I; 4 collections; AK 168748; on decaying log and epiphytic on kanuka; northernmost record.

Sematophyllum contiguum (Mitt.) Mitt. in Seeman
Great I; 4 collections; AK 26735; on rocks and epiphytic on *Cordyline kaspar*.

Sematophyllum homomallum (Hampe) Broth.
North East I; 1 collection; AKU 67886; on rocks and epiphytic on kanuka; northernmost record.

Thuidium furfurosum (Hook. f. & Wils.) Reichdt.
Great I; 13 collections; AKU 67925; apparently common, on ground under kanuka and manuka; recorded also by Turbott (1948).

Thuidium sparsum (Hook. f. & Wils.) Jaeg.
syn. T. furfurosum (Hook. f. & Wils.) Reichdt. var *sparsum* (Hook. f. & Wils.) Sainsb.
Great I; 1 collection; AK 26711; Tasman Stream.

Tortula papillosa Wils.
North East I, South West I; 3 collections; AKU 67896; on exposed rock; northernmost record.

Trichostomum brachydontium Bruch

Great I; 1 collection; CHR 164571; on clay at edge of pohutukawa forest remnant; northernmost record.

Excluded records

Brachythecium rutabulum (Hedw.) B.S.G.

Recorded by Horning *et al* (1978) on the basis of a specimen *leg.* G.W. Ramsay No.498, det. K.W. Allison. Examination of a duplicate in CHR (CHR 276579) reveals that this non-fruiting material is almost certainly *Rhynchostegium tenuifolium* (Hedw.) Jaeg.

Bryum truncorum (Brid.) Brid.

Recorded by Horning *et al* (1978) on the basis of several specimens *leg.* G.W. Ramsay. Following revision this species is now recognised in New Zealand as *Bryum billardieri* Schwaegr. (Ochi 1971). One specimen cited by Horning *et al*, No.497, is misidentified *Bryum campylothecium*.

Isopterygium albescens (Hook.) Jaeg.

syn. I. molliculum (Sull.) Mitt.

Recorded by Sainsbury (1955) from the Three Kings Islands. The specimen in Sainsbury's herbarium (WELT M7897) together with two specimens in AK, AK 26693 and AK 26694, together with a fourth specimen in CHR (Herb. K.W. Allison No. 4124) would appear to be all part of a single gathering by M. Holdsworth *s.n.* 15.i.1951 at Castaway Stream, Great I. The only other Three Kings specimen of *Isopterygium* that I located, *leg.* G.W. Ramsay 475, CHR 164551 is identified by K.W. Allison as *I. albescens* (Hook.) Jaeg. Both these collections have been determined by Z. Iwatsuki as *I.* cf. *minutirameum* (C. Muell.) Jaeg. *I. minutirameum* is an Asiatic species known from a number of localities in northern New Zealand.

Weisia controversa Hedw.

Recorded by Horning *et al* (1978) on the basis of a specimen *leg.* G.W. Ramsay No. 490, *det.* K.W. Allison. A duplicate in CHR (CHR 164571) is misidentified *Trichostomum brachydontium* Bruch.

Discussion

All moss species recorded here for the Three Kings Is are already known from the northern New Zealand mainland in coastal, and in some cases also from inland, habitats. Fourteen of the species have been recorded from the Kermadec Is, 1200 km to the north-east (Sykes 1977). For the other 22 species these Three Kings records are the northernmost in the New Zealand Botanical Region, *sensu* Allan (1961). Further bryological collection on the Kermadec Islands will no doubt reduce this number.

The species recorded reflect a diversity of habitats, both moist, such as stream banks and seepages, and dry, such as exposed rock. Terrestrial substrates, soil and rock are well represented, with, less frequently, rotten logs and trunks of trees. In spite of this habitat

diversity the total number of 36 species is small compared with lists of mosses prepared for other northern offshore island groups, such as the Hen and Chickens Is 65 species (Cranwell & Moore 1935), Chickens Is 62 species (Beever 1984), Poor Knights Is 59 species (Beever 1986) and Little Barrier I 126 species (Beever unpublished data). Furthermore all species recorded from the Three Kings Is are relatively conspicuous. There is no doubt that further bryological exploration of the Three Kings would reveal a far richer moss flora than is at present recorded.

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A PRELIMINARY LIST OF THE HEPATICAE (LIVERWORTS) AND ANTHOCEROTAE (HORNWORTS) FROM THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. A preliminary list of 20 taxa (19 hepatics and one anthocerotae) from the Three Kings Islands is provided, based on collections held at the Auckland Institute and Museum and the herbarium, Botany Department, University of Auckland. The species reported are also found in other northern localities in mainland New Zealand. Comparison with other offshore islands and with northern mainland localities suggests that a richer flora should be expected on the Three Kings Islands.

Collections of liverworts have been made from the Three Kings Islands on several occasions, the major collections being those made by M. Holdsworth in 1951 and by A.E. Wright and E.K. Cameron in 1983. In addition, there are a few other specimens at CHR collected by G.W. Ramsay in 1970 and at AK by B.W. Hayward in 1983. The only published reference to hepatics is to a collection of *Riccardia* sp. (Horning et al. 1978:276). The plant concerned is treated as *Aneura* sp. in this list.

A number of specimens are represented in collections as minor inclusions in specimens of other larger and more conspicuous species, e.g. the specimen of *Megaceros flagellaris* (A.E. Wright AK 168775) contains three accessory species *Chiloscyphus* sp., *Kurzia ?hippuroides* and *Teleranea tetradactyla.*

Annotated list of the Hepatics and Anthocerotae

For each species, records are given for individual islands within the Three Kings group, together with the total number of collections examined by me. The specimen number of a selected voucher is cited as well as a summary of the habitat data given by collectors. All records, except that for *Marchantia foliacea*, appear to be the northernmost records for the taxa concerned in the New Zealand Botanical Region but it seems likely that some will be found in the Kermadec Is with further collection there.

Names used in the list are based on the checklists of Hamlin (1972, 1973), and for Anthocerotae the more recent paper by Campbell (1984).

HEPATICAE

Aneura (subg. *Lobatiriccardia*) sp.
Great I; four collections; AK 26078; Tasman Stream, on soil.

Archilejeunea olivacea (Hook.f. & Tayl.) Steph.,
Great I; one collection; AKU 067913; Quadrat I, on *Litsea* bark.

Balantiopsis diplophylla (Hook.f. & Tayl.) Mitt. (syn. *B. hockenii* Berggr.)
Great I; 3 collections; AK 26717, on soil.

Cheilolejeunea (subg. *Euosmolejeunea*) sp.
Great I; one collection; AKU 0674914, Quadrat I, on *Litsea* bark.

Chiloscyphus compactus Col.
Great I; three collections; AK 26713, Castaway Stream; Quadrat II; one collection; AK 22011.

Chiloscyphus sp.
Great I; one collection; AK 168775, Tasman Stream, with *Megaceros* on clay soil.

Cololejeunea pulchella (Mitt.) Schust.
Great I; one collection; AKU 067922; Quadrat I, on bark on *Melicytus ramiflorus*.

Frullania rostellata Mitt.
Great I; five collections; AKU 067910; Quadrat I and Castaway Valley on bark of *Melicytus* sp., *Kunzea ericoides* and *Cordyline*. West I; two collections; AKU 067905, on *Meryta sinclairii* bark. South West I; two collections; AK 168772, on bark of *Meryta sinclairii* and *Cordyline kaspar*.

On the basis of available collections this is the commonest epiphytic liverwort on these islands. This species is common in coastal sites in northern New Zealand.

Frullania solanderiana Col.

North East I; one collection; AKU 067888, on *Kunzea ericoides* bark. West I; two collections; AKU 067903, on rock. South West I; three collections; AK 168785, on rock and bark (*Meryta sinclairii*).

As is common with this species from other locations specimens rarely show fully developed lobules most of the material being only explanate lobules.

Hymenophyton flabellatum (Labill.) Dum. ex Trev.
Great I; four collections; AK 168760, Tasman Stream, on clay soil and humus.

Kurzia sp. [?*K. hippuroides* (Hook. f. & Tayl.) Groelle]
Great I; one collection; AK 168775, Tasman Stream. With *Megaceros* on clay soil.

This is fragmentary material.

Lejeunea flava (Sw.) Nees
Great I; two collections; AKU 067915, Quadrat I, on bark (*Litsea, Melicytus, Leptospermum*). South West I; two collections; AK 168771, on bark (*Meryta sinclairii*). North East I; one collection; AKU 067889 on bark (*Leptospermum*).

Lophocolea bidentata (Linn.) Dum.
North East I; one collection; AKU 067887, on bark (*Leptospermum*). South West I; one collection; AK 168757, on clay.

Lophocolea subporosa Mitt.
South West I; one collection; AKU 067899, on clay.

Marchantia foliacea Mitt.
Great I; two collections; AK 26724, Tasman Stream, on soil.

Metzgeria furcata (Linn.) Dum. (including and equivalent to *M. vittii* Kuwahara)
Great I; six collections; AK 26719, Tasman Stream 90 m alt, on humus or bark. South West I; two collections; AKU 067893.

This species keys to *M. vittii* on the basis of occasional to common geminate hairs on the margin of the thallus.

Microlejeunea culcullata (Reinw. et al.) Steph.
Great I; one collection AKU 067919, Quadrat I, on bark of *Kunzea ericoides*.

Siphonolejeunea nudipes (Hook.f. & Tayl.) Herz.
West I; one collection; AKU 067904, on rock surface.

Teleranea tetradactyla (Hook.f. & Tayl.) Hodgs.
Great I; one collection; AK 168775, Tasman Stream, in with *Megaceros* on clay soil.

The collection is fragmentary material of this small but distinctive species.

ANTHOCEROTAE

Megaceros flagellaris (Mitt.) Steph.
Great I; three collections; AK 168775; Tasman Stream and Castaway Stream, all on clay soil, 90-120 m alt.

Discussion

The specimens in herbaria fall into two groups. Most are large conspicuous species growing on soil (or are small species collected accidentally in samples of such large species). The rest are epiphytes on bark of forest trees (mostly collected at my request by E.K. Cameron in 1983).

Experience with collections from Little Barrier I, The Aldermen Is, the Poor Knights Is and in forest in Northland indicates that a much richer hepatic flora is to be expected on the Three Kings than is indicated by this list. Given the relatively rich and varied vegetation of these islands, the range of epiphytes in particular is, at this stage, very limited. Future exploration will also certainly extend the number of terrestial hepatics.

In some cases the available collections are inadequate for fully accurate determination of the taxa concerned. Also a few species, though distinctive, are represented by only fragmentary samples; thus further collections are needed.

Often the specimens are sterile. With more rigorous collecting, fertile material of many of these could probably be located. This would allow more accurate identification, which would also be improved by the availability of fresh material as some critical identifying features are only satisfactorily present in live plants.

On the basis of the samples available and by comparison with other sites it appears that the Three Kings Islands have an hepatic flora essentially similar to that of forested coastal areas in northern New Zealand. Collections so far are limited in extent as no experienced hepaticologist has visited the islands. More species are to be expected with further collecting. At this stage there is no evidence of island endemics.

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LICHENS FROM THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. One hundred and sixty nine lichen taxa in 81 genera are recorded from the Three Kings Islands, northern New Zealand. Although most records are from Great Island, the list also includes collections from North East Island, South West Island and West Island. More than half of the lichens recorded are cosmopolitan (35%) species or New Zealand endemics (20%), with the remainder showing the following affinities: australasian (17%), pantropical (13%), austral (7%), palaeotropical (5%) and Western Pacific (3%). A distinctive perlatolic acid-containing strain of *Neofuscelia pulla* appears to be confined to the Three Kings Islands. Great Island is the type locality for *Erioderma sorediatum*. *Endocarpon* cf. *adscendens*, *Phyllopsora* cf. *haemophaea* and *Pyxine cocoes* are additions to the New Zealand lichen flora, and an undescribed species of *Trapeliopsis* occurs on *Metrosideros excelsa* bark.

The Three Kings Islands consist of one large island (Great I), three smaller ones (North East I, South West I and West I) and a chain of bare or scrub-covered rocks (Princes Is) in the southern Pacific Ocean (Lat.*c*. 34° 6′S: Long. 172° 20′E) some 53 km northwest of Cape Maria van Diemen, northern New Zealand (Fig.1). The islands range in size from less than 20 hectares to 3500 hectares, and Great I attains an altitude of 283 m. The islands are affected by a warm current so that climate is humid, with much mist or fog conducive to a dense plant cover in some areas (Cranwell 1962). Rainfall is probably rather similar to that for the far north of New Zealand with extended dry periods in the summer. Frequent coastal fog keeps epiphytic vegetation moist for reasonable periods, though nowhere is there a luxuriant epiphytic plant cover characteristic of areas of warm temperatures and high rainfall such as are common in very many parts of New Zealand. Separation from the New Zealand mainland has been effective for a long time, perhaps from the Lower Tertiary (Cranwell 1962).

As a result of Cheeseman's discovery of several local endemic taxa (Cheeseman 1888, 1891) [*Alectryon grandis, Coprosma macrocarpa, Davallia tasmanii, Hebe insularis, Paratrophis smithii* (= *Streblus smithii*), *Pittosporum fairchildii*], Cockayne (1921) proposed a separate Three Kings botanical district as part of the North Auckland Botanical Province. The vascular flora comprises nearly 180 species with 13 of these locally endemic, a surprising number for such a small geographical area and probably representing "... a portion of the Pleistocene survivors which never regained mainland habitats" (Wardle 1963). Although much interest has focussed on the Three Kings flora and on the processes of regeneration following the extermination of a large population of goats in 1946 (Baylis 1948; Oliver 1948; Turbott 1948; Baylis

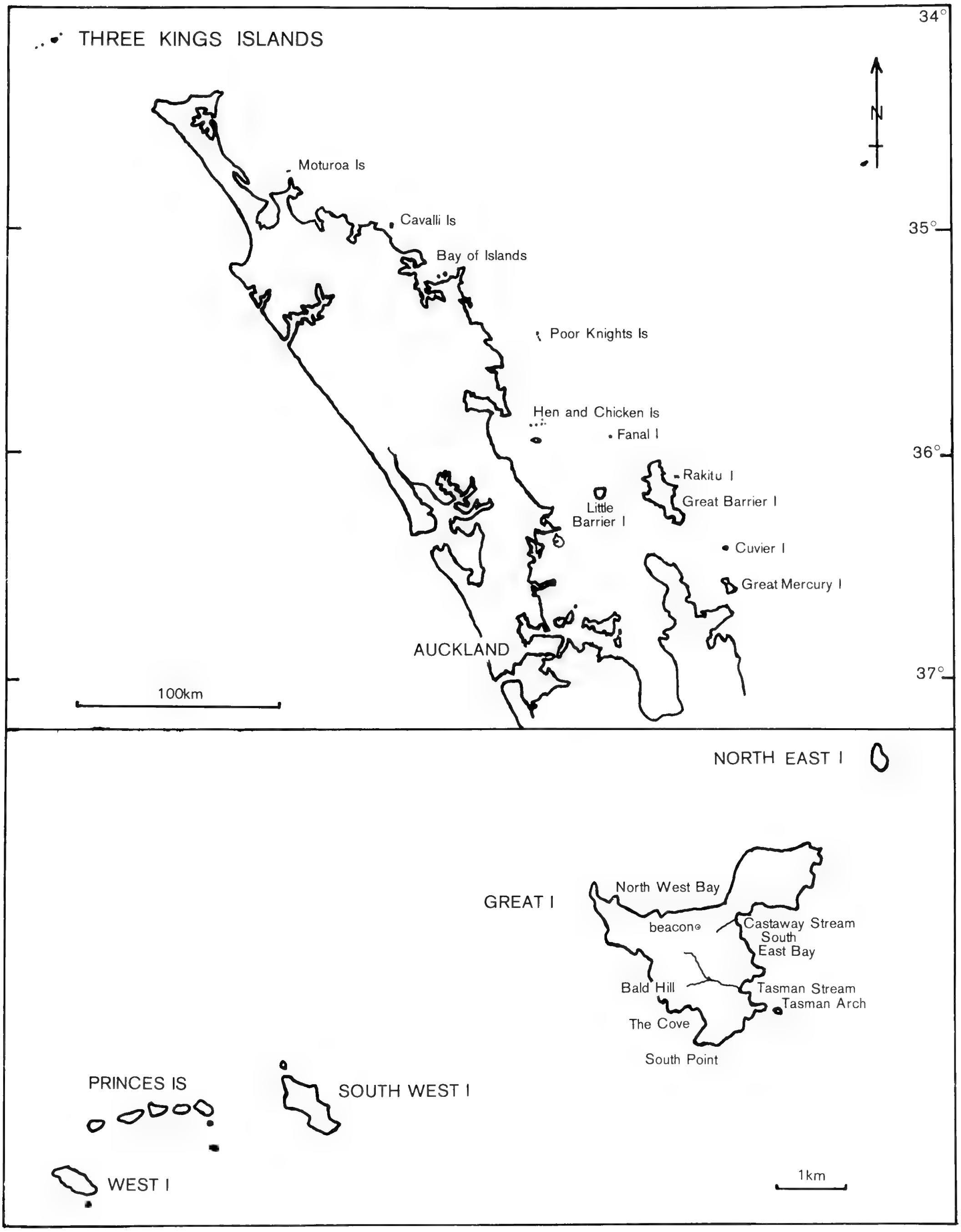

Fig. 1. Location of northern off-shore islands and map of Three Kings Islands.

1951a,1951b; Holdsworth 1951; Baylis 1958; Cranwell 1962; Turbott 1963; Holdsworth & Baylis 1967; Wright 1983), at present little is known of the lichens to be found there apart from occasional references in particular generic accounts, based on collections made by one of us (D.J.G.) in 1970. These include *Erioderma sorediatum* (Galloway & Jørgensen 1975), *Parmelia pulla, P.verrucella* (Esslinger 1977; Culberson, Culberson & Esslinger 1977), *Opegrapha agelaeoides, Phaeographis australiensis* (Hayward 1977), *Parmeliella pycnophora* (Keuck 1977), *Coccocarpia erythroxyli, C.palmicola, C.pellita* (Arvidsson & Galloway 1979; Arvidsson 1983), *Stereocaulon corticatulum, S.ramulosum* (Galloway 1980), *Xanthoparmelia australasica, X.conspersa, X.furcata, X.mexicana, X.scabrosa, X.tinctina* (Galloway 1981), *Porpidia albocaerulescens* (Hertel & Knoph 1984), *Xanthoparmelia streimannii, X. tasmanica* (Elix et al. 1986), and *Haematomma saxicola* (Rogers & Bartlett 1986).

The present study records the macrolichens and a number of microlichens collected on the Three Kings Is in 1970, 1982 and 1983. In November 1970 D.J.G. spent one month on Great I (including a day on South West I), during an expedition organised by Entomology Division, D.S.I.R. (Ramsay 1971). B.W.H. visited the Three Kings Is in December 1982 and December 1983, spending a total of 12 days on Great I and making landings on West, North East and South West Is. Lichens collected on these visits are discussed below. Studies on the microlichens collected are still incomplete and will be reported at a later date. Voucher specimens of lichens collected on the Three Kings Is are held in the herbarium of the Auckland Institute and Museum (B.W.H. and some of D.J.G.), and in the herbaria of Botany Division, D.S.I.R., Lincoln (D.J.G.), and the British Museum (Natural History), London (D.J.G.).

Lichens are arranged alphabetically by species and genus. Except where otherwise stated, nomenclature follows Galloway (1985). Islands are abbreviated as follows: Great I (G), South West Is (SW), West I (W), North East I (NE).

Species list

Habitat:
1 maritime
2 cliff ridges and faces
3 cliff tops
4 coastal forest
5 *Leptospermum* forest
6 regenerating forest (including *Meryta sinclairii, Coprosma macrocarpa* etc.)
7 inland outcrops and clearings, Tasman Stream bed
8 pohutukawa
9 exposed scrub (Bald Hill, south side of Tasman Valley, South Point)
10 original forest remnants (*Pennantia baylisiana, Vitex lucens* etc.)

Substrate:
r = rock
b = bark
s = soil
w = decorticated wood
l = leaves

List Of Lichens Of Three Kings Islands

Arthonia knightii	4b, 6b (G)
Bacidia albidoplumbea	5w (G)
B.buchananii	4bs, 10b (G)
Brigantiaea chrysosticta	2r (G)
Buellia stellulata	2r (G)
Caloplaca cribrosa	1r (G), 3r (NE)
C.inclinans	4b, 6b (G)
C.mooreae	4b (SW)
C.sublobulata	1r (G)
Candelaria concolor	2r (G)
Candelariella xanthostigma	5b (G)
Catillaria melanotropa	4b, 5b (G)
Chrysothrix candelaris	4b, 5b, 6b, 8b (G), 4b (SW)
Cladia aggregata	3s, 4s, 5s, 6s, 7rs, 8bs, 9rs (G)
Cladina confusa (R.Sant.) Follm. & Ahti (Ahti 1984)	5s, 9s (G)
Cladonia capitellata	5s, 7r, 8s, 9s (G)
C.carassensis	3s (G)
C.cervicornis	3s, 5s, 9s (G)
C.cervicornis ssp. *verticillata*	5s (G)
C.corniculata Ahti & Kashiwadani (Ahti & Kashiwadani 1984)	9s (G)
C.cornuta	5s (G)
C.enantia	2s, 8s, 9s (G)
C.fimbriata	5s, 9s (G)
C.floerkeana	5sw, 9s (G)
C.gracilis ssp. *tenerrima*	5s (G)
C.krempelhuberi	9s (G)
C.macilenta	5s (G)
C.neozelandica	3s (G)
C.ochrochlora	2s, 3s, 5w, 9s (G)
C.polycarpoides	3s, 5s, 7r, 8b, 9s (G)
C.ramulosa (With.) Laundon (Laundon 1984)	3s, 5s (G)
C. cf *rigida*	3s (G)
C.scabriuscula	5s, 9s (G)
C.squamosula	3s (G)
C.wilsonii Archer (Archer 1984)	5s, 9s (G)
Clathroporina exocha	4b, 10br (G)
Coccocarpia erythroxyli	5b, 6b (G)
C.palmicola	5br, 7r, 8b (G)
C.pellita	7r, 8b (G)
Coccotrema porinopsis	8b (G)
Coenogonium implexum	10b (G)
Collema coccophorum	2r (G)
C.glaucophthalmum	4b (SW)
C.laeve	4b, 5b, 6b (G), 4b (SW)
Dictyonema moorei	5b (G)
Diplotomma alboatrum	2r (G)
Dirinaria applanata	4b (SW)
D.picta	4b, 8b (G)
Endocarpon cf. *adscendens* (Anzi) Müll.Arg.	2r (G)
Erioderma sorediatum	5b, 8b, 9b (G)

Flavoparmelia euplecta (Stirton) Hale (Hale 1986)	7r (G)
Graphina subvelata	4b (G)
Gymnoderma melacarpum	8b (G)
Haematomma saxicola R.W. Rogers (Rogers & Bartlett 1986)	2r, 3r (G), 3r (SW)
Heterodermia japonica	2r, 3s, 9s (G)
H.leucomelos ssp. *boryi*	3s, 4b, 5b (G)
H.obscurata	5b (G), 4b (SW)
H.speciosa	3s, 5b (G)
Hyperphyscia adglutinata	5b (G)
Hypotrachyna formosana	3r, 5r, 7r (G)
Lecanactis redingeri	5b (G)
Lecanora atra	2r, 3r, 7r, 9r (G)
L.campestris	2r, 3rs (G)
L.dispersa	1r (G)
L.flavopallida	3b, 5bw (G)
Lecidea cerinocarpa	4b (SW)
L.conisalea	4b, 6b (G)
L.fuscocincta	4bs, 5b (G)
Lecidella schistiseda	2r, 7r (G)
Leioderma pycnophorum	5b, 6b, 9b (G)
Lepraria incana	7rs (G)
Leprocaulon arbuscula	7r (G)
Leptogium azureum	3b, 4b, 5b (G), 4b (SW)
L.brebissonii	5b (G)
L.crispatellum	3bs, 4s, 5b (G)
L.cyanescens	4bs, 7r, 10b (G), 4b (SW)
Megalospora gompholoma	5bw (G)
Melaspilea subeffigurans	4b (G)
Miltidea ceroplasta (Church.Bab.) D. Galloway & Hafellner (Hafellner 1984)	5b (G)
Neofuscelia pulla	2r, 5r (G)
N.verrucella	2r, 3r, 7r (G)
Normandina pulchella	8b, 10b (G)
Ochrolechia parella	2r, 9r (G)
O. cf *thelotremoides*	4b, 6b (G)
Opegrapha agelaeoides	4b (G)
O.intertexta	4b, 6b (G), 4b (SW), 4b (W)
O.spodopolia	5r (G)
Pannaria elatior	4b, 5b, 6b (G)
P.fulvescens	5b, 9b (G)
P.subimmixta	2r (G)
Paraparmelia scotophylla (Kurok.) Elix & Johnston (Elix, Johnston & Verdon 1986)	1r (G)
Parmeliella mucorina	4b (G)
P.nigrocincta	5b (G)
Parmotrema cetratum	2r, 3r, 7r, 8b, pr (G), 2r (SW)
P.chinense (Osbeck) Hale & Ahti (Hale & Ahti 1986)	2r, 5b (G), 3b (W)
P.crinitum	2r, 4b, 5b (G), 4b (SW)
P.cristiferum	5b (G)
P.grayanum	2r, 3r (G)
P.mellissii	5b (G)
P.reticulatum	2r, 3r, 5rw, 7r, 8br, 9r (G), 4b (SW)

P.subtinctorium	9r (G), 4b (SW), 4b (W)
P.tinctorum	3r, 4b, 5br, 8b, 9r (G), 4b (SW)
Peltigera dolichorhiza	5s (G)
P.nana	5s, 6s (G)
Peltula euploca	2rs (G)
Pertusaria lavata	7r (G)
P.melaleucoides	5b (G)
P.novaezelandiae	5b, 8b, 9b (G)
P.sorodes	5b, 8b (G)
P.superba	7r (G)
Phaeographis australiensis	6b (G), 6b (SW)
Phaeophyscia orbicularis	2r, 5b (G)
Phlyctella uncinata	4b (G), 9b (NE), 4b (SW)
Phyllopsora cf. *haemophaea* (Nyl.) Müll.Arg	5b (G)
P.microdactyla	4b, 10b (G)
Physcia tenuisecta	5b, 8b (G)
P.tribacioides	5b, 10b (G)
Physconia grisea	3rs, 5b (G)
Placopsis parellina f. *argillacea*	2s (G)
Poeltiaria turgescens (Koerber) Hertel (Hertel 1984)	1r, 2r (G)
Porpidia albocaerulescens (Wulfen) Hertel & Knoph (Hertel & Knoph 1984)	2r, 5r, 7r, 9r (G)
Pseudocyphellaria aurata	4b, 5b, 7r, 9b (G), 6b (SW)
P.carpoloma	5b (G)
P.chloroleuca (Galloway 1986)	2r, 4b, 5b, 6b, 8b (G)
P.crocata	2r, 5s, 7r (G)
P.episticta	4b, 5b, 7s, 8b, 10b (G)
P.flavicans	2r, 5b (G)
P.montagnei	5b, 6b (G)
P.poculifera	2r, 3r, 4b, 5b, 6b, 7b, 8b (G)
Pseudoparmelia pseudosorediosa	2r, 5br, 7b, 9b (G)
Psoroma allorhizum	3r, 5b (G)
P.araneosum	2r, 3r, 4b, 5b (G)
P.pholiodotoides	4b, 5b (G)
Punctelia borreri	4b (SW)
Pyrenothrix nigra	5b (G)
Pyrenula crassescens	4b, 6b (G)
P. cf *moniliformis*	4b (G)
Pyxine cocoes (Sw.) Nyl.	4b (SW)
Ramalea cochleata	7s (G)
Ramalina australiensis Nyl. (Stevens 1987)	1r, 2r, 3b, 5b, 8b, 9b (G), 4r (NE)
R.celastri	1r, 2r, 3r, 7r (G), 4b (SW), 4r (NE)
R.pacifica	2r, 3r, 4b, 5b (G)
R.peruviana	5b (G)
Rhizocarpon viridiatrum	2r (G)
Rinodina thiomela	1r, 2r (G)
Sphinctrina tubiformis	2r (G)
Stereocaulon corticatulum	9rs (G)
S.ramulosum	2r, 3r, 5s, 7r, 8s, 9rs (G)
Sticta latifrons	3b, 4b, 5b, 6b, 10b (G)

S.squamata	4b, 5b, 6b, 8b, 9b (G)
Strigula elegans	4l (W)
Teloschistes flavicans	2r, 3br, 4b, 5b, 8b, 9b (G), 4r (NE), 3r, 4b (SW), 3b, 4b (W)
Thelotrema lepadinum	5b (G)
Trapeliopsis granulosa (Hoffm.) H.T. Lumbsch (Coppins & James 1984)	5bs (G)
Trapeliopsis sp.	8b (G)
Usnea arida	2b, 3b, 5b, 8b, 9b (G), 4b (SW)
U.oncodes	9b (G)
U.rubicunda	2b, 3b, 5b, 7r (G)
U.societatis	2r, 3br, 5b, 6b, 7r, 8b, 9b (G)
Verrucaria maura	1r (G), 1r (SW)
Xanthoparmelia australasica	2r, 3r, 9r (G), 3r (NE)
X.furcata	2r, 3r, 9r (G)
X.mexicana	2r, 3r (G)
X.scabrosa	2r (G)
X.streimannii (Elix & P.Armstr.) Elix & Jen Johnston (Elix & Armstrong 1983; Elix, Johnston & Armstrong 1986)	2r, 3r, 9r (G)
X.tasmanica	9r (G)
X. tinctina	7r (G)
Xanthoria ligulata	1r, 2r (G), 3r (NE)
X.parietina	1r (G), 1r, 4b (SW), 3r (NE)

FLORISTIC DIVERSITY

In this paper we record 169 lichen taxa in 81 genera from the Three Kings Is. These numbers are compared with those from other northern offshore islands (Fig.1) in Table 1.

Table 1. Numbers of lichen species and genera from northern offshore islands.

Islands	Species	Genera	Source
Three Kings Is	169	81	This work
Motorua Is	21	15	G.C. Hayward & Wright 1977
Cavalli Is	85	39	B.W. Hayward & Hayward 1979
Eastern Bay of Islands	111	43	B.W. Hayward & Hayward 1980
Poor Knights Is	132	52	unpublished — see also B.W. Hayward & Hayward 1982a
Hen and Chicken Is	156	58	G.C. Hayward & Hayward 1978 B.W. Hayward & Hayward 1984
Fanal I	58	31	Wright et al. 1980
Little Barrier I	170	67	unpublished
Rakitu I	124	50	B.W. Hayward & Hayward 1982b
Great Barrier I	252	79	Dakin & Galloway 1980 B.W. Hayward et al. 1986
Cuvier I	49	28	B.W. Hayward et al. 1981
Great Mercury I	104	41	G.C. Hayward et al. 1976

The lichen flora of the Three Kings Is appears to be more diverse than that of any other island or island group north of Lat 36° S. This is probably best explained by the large number of different habitats available for colonisation, and reasonably extensive areas of successional vegetation in adequate light where lichens are always fairly richly developed. The length of time spent in intensive search would also account for some, but not all, of the apparent greater diversity on the Three Kings Islands. In time, with the re-establishment of the mixed coastal forest and the consequent reduction of light resulting from a more or less closed canopy, a reduction in both numbers and diversity of the lichens present can be expected.

LICHEN COMMUNITIES AND HABITATS

Maritime

The only maritime habitats visited were the landing places at North West Bay and South East Bay on Great I and the landing platform in the small harbour at the north end of South West I. Here *Verrucaria maura* occurs intertidally and several yellow-orange lichens dominate the rocks above high tide; species of *Caloplaca* (*C.cribrosa, C.sublobulata*) and *Xanthoria* (*X.ligulata, X.parietina*), with the orange-red, narrow-lobed *X.ligulata* being most common. Tufts of *Lichina confinis*, normally found intertidally with *V.maura*, were not observed.

Cliff face and ridges

Great I is surrounded by high cliffs, several of which on their upper slopes have exposed, traversable areas of rocks or soil. This zone which extends from high water mark to coastal scrub or forest, is very rich in lichens, especially small saxicolous and terricolous species, most of which will be the subject of a later paper. Most conspicuous lichens in this zone are the large, grey, foliose species of *Parmotrema*, the yellow foliose or subfruticose thalli of *Xanthoparmelia*, the orange-red straggling tufts of *Teloschistes flavicans* and the green-grey or yellowish tufts of *Ramalina* and *Usnea*. On rocks towards the top of the North West landing slope, the scarlet apothecia of the crustose *Haematomma saxicola* are locally noteworthy. Important lichens in this zone include: *Candelaria concolor, Collema coccophorum, Diplotomma alboatrum, Endocarpon* cf *adscendens, Heterodermia japonica, Lecanora atra, L.campestris, Lecidella schistiseda, Neofuscelia pulla, N.verrucella, Ochrolechia parella, Pannaria subimmixta, Parmotrema cetratum, P.chinense, P.crinitum, P.grayanum, P.reticulatum, Peltula euploca, Phaeophyscia orbicularis, Placopsis parellina* f. *argillacea, Poeltiaria turgescens, Porpidia albocaerulescens, Pseudocyphellaria crocata, P.poculifera, Psoroma araneosum, Ramalina celastri, R.pacifica, R.australiensis, Rinodina thiomela, Stereocaulon ramulosum, Usnea societatis, Xanthoparmelia furcata, X.mexicana, X.scabrosa* and *Xanthoria ligulata.*

Open cliff tops

Pohutukawa (*Metrosideros excelsa*) and kanuka (*Leptospermum ericoides*) are common trees on the cliff tops surrounding Great I, though in many places open, rocky clearings occur where trees give way to stunted shrubs. In such situations where light is

plentiful a characteristic lichen vegetation is met with. On trees the most noticeable lichens are the orange-red *Teloschistes flavicans* and the yellow-green, pendulous *Ramalina australiensis*. Associated bark lichens included: *Lecanora flavopallida, Leptogium azureum, L.crispatellum, Sticta latifrons, Usnea arida, U.rubicunda* and *U.societatis*. On rock the main lichens are: *Hypotrachyna formosana, Neofuscelia verrucella, Parmotrema cetratum, P.reticulatum, P.tinctorum, Physconia grisea, Pseudocyphellaria poculifera, Psoroma allorhizum, P.araneosum, Ramalina celastri, Teloschistes flavicans, Usnea societatis, Xanthoparmelia furcata, Xanthoria ligulata* and *X.parietina*.

Coastal forest

Here are included forest trees and understory shrubs that occur on Great I at, or near cliff tops around the coast, and along the Tasman Stream, and also on South West I. Major phorophytes include: *Coprosma macrocarpa, C.rhamnoides, Cordyline kaspar, Litsea calicaris, Melicytus ramiflorus, Metrosideros excelsa, Meryta sinclairii, Cyathea medullaris*. The extensive areas of *Leptospermum* (especially in Castaway Valley, the Tasman Valley and the north-east peninsula) and the stands of pohutukawa on Great I are dealt with separately, as are the scattered remnants of the original forest of the island.

In the canopy of coastal forest where high light conditions prevail, the fruticose taxa *Ramalina australiensis, Teloschistes flavicans* and *Usnea* species (*U.arida, U.rubicunda, U.societatis*) are most common. Bark species include: *Caloplaca inclinans, C.mooreae, Catillaria melanotropa, Chrysothrix candelaris, Clathroporina exocha, Collema glaucophthalma, C.laeve, Dirinaria applanta, D.picta, Lecidea cerinocarpa, L.fuscocincta, L.conisalea, Leptogium crispatellum, L.cyanescens, Pannaria elatior, Parmeliella mucorina, Phlyctella uncinata, Phyllopsora microdactyla, Pseudopcyphellaria aurata, P.episticta, P.poculifera, P.chloroleuca, Psoroma araneosum, P.pholidotoides, Pyxine cocoes* (on *Meryta*, South West I), *Sticta latifrons* and *Xanthoria parietina*.

On the ground there is normally severe competition from grasses, sedges and mosses and there are generally few lichens. Those present include: *Cladia aggregata, Bacidia buchananii, Leptogium crispatellum, Peltigera dolichorhiza* and *Stereocaulon ramulosum*.

Coprosma macrocarpa is nearly always completely devoid of lichens although the inconspicuous crustose *Melaspilea subeffigurans* was only found on its bark. *Cyathea medullaris* is poorly colonised except for *Bacidia buchananii, Lepraria* and occasional colonies of *Pseudocyphellaria episticta*. *Cordyline kaspar* in favourable sites (especially in the lower courses of eastern tributaries of the Tasman stream) supports a number of lichens, mainly *Sticta latifrons, Pseudocyphellaria chloroleuca* and species of *Parmotrema*, though occasionally large colonies of *Catillaria melanotropa* occur on this substrate. Rarely, colonies of *Pseudocyphellaria carpoloma* and *P. montagnei* grow on the bark of this tree.

Leptospermum *forest*

This covers wide areas of Castaway Valley, Tasman Valley and most of the north-eastern part of Great I (Baylis 1951b, Holdsworth & Baylis 1967). *Leptospermum ericoides* is the present climax tree cover and older trees are more heavily colonised with lichens than are young trees whose canopies tend to be too dense to allow sufficient light to penetrate to primary branches where lichens tend to grow. In open situations and at lower levels the dominant lichens of *Leptospermum* bark are (in order of importance): *Pseudocyphellaria poculifera, P.episticta, P.flavicans, P.chloroleuca, Sticta latifrons, S.squamata, Parmotrema cetratum, P.crinitum, P.reticulatum, P.tinctorum, Psoroma allorhizum, P.pholidotoides, Megalospora gompholoma.* More rarely are found: *Coccocarpia palmicola, Leioderma pycnophorum, Leptogium azureum, L.brebissonii, L.crispatellum, L.cyanescens, Pannaria elatior, Pertusaria sorodes, Pyrenothrix nigra* and *Thelotrema lepadinum.* At the highest elevations on Great I and especially near cliff tops, pendulous, fruticose species of *Ramalina*,and *Usnea* are common (dead species of *Leptospernum* also tend to be well covered by species of these two genera regardless of where they occur) often in association with *Teloschistes flavicans.* This last species is a brilliant yellow-, or orange-red in well lit sites, becoming pale yellow in shade. Above about 180 m, the major epiphyte of trunks of *Leptospermum* is *Sticta latifrons* and, to a lesser extend, *Pseudocyphellaria chloroleuca,* both of these species persisting on old trunks in quite low-light situations where few other lichens are present. *Heterodermia leucomelos* ssp. *boryi* was collected only rarely from *Leptospermum* near the summit of Great I, although it occurs in coastal scrub south of the Tasman Arch. On the ground under *Leptospermum* where light is sufficient several lichens occur, most notably *Cladia aggregata, Cladina confusa* (especially in the north-east peninsula), *Stereocaulon ramulosum* and several species of *Cladonia* (*C.capitellata, C.cervicornis, C.cornuta, C.fimbriata, C.macilenta, C.polycarpoides*). In some places terricolous or muscicolous communities are quite well developed and include species of *Leptogium, Parmotrema, Psoroma* and *Pseudocyphellaria*, obviously derived from the nearby corticolous communities on *Leptospermum.*

Regenerating forest

This includes tree species and understorey shrubs other than *Leptospermum* or *Metrosideros*, and comprises most trees found in habitat 4 (above) including: *Brachyglottis arborescens, Coprosma macrocarpa, C.rhamnoides, Corynocarpus laevigatus, Cordyline kaspar, Meryta sinclairii, Melicytus ramiflorus, Litsea calicaris,* and *Pittosporum fairchildii.*

Meryta (puka) is at present the dominant tree in this habitat (especially on Great, South West and North East Is) and supports a small but exceedingly interesting lichen community on its smooth bark. Crustose lichens tend to be more common on this phorophyte than foliose or fruticose ones as the crown of large glossy leaves greatly reduces the light available to foliose and fruticose epiphytes. In large trees (such as those on South West I) a number of macrolichens occur on *Meryta* including: *Parmotrema subtinctorium, P.tinctorum, Pseudocyphellaria aurata, P.poculifera, Punctelia borreri, Ramalina celastri, R.pacifica, Usnea arida* and *U.societatis.* The

foliose tropical lichen *Pyxine cocoes* also occurs on this phorophyte on South West I but not yet apparently on Great I. Microlichens from *Meryta* include: *Caloplaca inclinans, Arthonia knightii, Chrysothrix candelaris, Graphina subvelata, Lecidea conisalea, Opegrapha intertexta, Phaeographis australiensis, Phlyctella uncinata* and *Pyrenula crassescens.*

Inland outcrops and clearings including Tasman stream bed

These include prominent rock outcrops above the Castaway Depot site in Castaway Valley on the ridges leading to the lighthouse beacon, and several small outcrops in the Tasman Valley, and the bed of the Tasman stream. On soil in these areas the dominant lichens in all sites are *Cladia aggregata*, several species of *Cladonia*, and *Stereocaulon ramulosum*. A number of species of *Parmotrema* are encountered (mainly *P.reticulatum*) and in some sheltered sites saxicolous *Usnea societatis* may develop. Most of the lichen cover of these areas is contributed by saxicolous microlichens which will be reported upon in a subsequent paper.

Metrosideros excelsa *trees*

The pohutukawa grove below Bald Hill in Tasman Valley, and the patch below the cliff top on the north-west coast in the vicinity of the sole surviving tree of *Pennantia baylisiana* were visited, as well as clumps south of Tasman Arch and at South Point. Pendulous species of *Ramalina* and *Usnea* are strikingly developed on pohutukawa, draping the trunks from canopy to the ground. Dominant species are *Ramalina australiensis* and *Usnea societatis*, with *Teloschistes flavicans* developed on trunks exposed to high light and salt-laden winds. Besides the dominant pendulous lichens mentioned, the bark of pohutukawa supports a diverse lichen flora, notable taxa including: *Coccocarpia palmicola, C.pellita, Coccotrema porinopsis, Erioderma sorediatum, Normandina, pulchella, Pertusaria novaezelandiae, Physcia tenuisecta* and a distinctive, undescribed species of *Trapeliopsis.*

Exposed scrub

Areas of exposed scrub (including *Hebe insularis*, stunted *Leptospermum* and *Metrosideros*) and ± bare patches of soil occur most notably on Bald Hill, the south side of Tasman Valley and at South Point above The Cove. On soil, *Cladia aggregata*, and *Stereocaulon* are dominant lichens, with *S.ramulosum* being represented (sometimes in swards) in all localities, and the sorediate *S.corticatulum* much less commonly developed. Species of *Cladonia* (the red-fruited *C.floerkeana* is locally common on Bald Hill) are frequently encountered as well as species of *Heterodermia, Ramalina, Parmotrema* and *Xanthoparmelia* growing on stones and rocks. Prostrate kanuka and *Coprosma rhamnoides* support several lichens the most common of which are *Coccocarpia erythroxyli, Erioderma sorediatum* [the type locality for this species is *Leptospermum* scrub on the south side of Tasman Valley (Galloway & Jørgensen 1975)], *Leioderma pycnophorum, Pannaria fulvescens, Pseudocyphellaria aurata* and *P.poculifera.*

Original forest remnants

Under this heading we include *Alectryon grandis, Brachyglottis arborescens, Pennantia baylisiana, Nestegis apetala, Heimerliodendron brunonianum, Pittosporum fairchildii, Streblus smithii* and *Vitex lucens.* All of these species are broad-leaved trees growing in ± dense shade. *Pennantia baylisiana* is an exception to this, the solitary surviving specimens (as seen in 1970) growing on a reasonably open rock scree. The site has now ". . . regenerated almost beyond recognition with a thick cover of ferns and herbs, and the base of the *Pennantia* is now obscured by a dense growth of its own shoots" (Wright 1983:181). The dominant corticolous lichen on *P.baylisiana* is *Clathroporina exocha* (in 1970 this lichen covered 15-20% of the bark surface) and this species also colonises rocks close to the roots of the tree. Significantly it is also developed on the other phorophytes mentioned but is not found elsewhere. Other lichens growing in the rather shaded conditions offered by these phorophytes include *Bacidia buchananii, Coenogonium implexum, Leptogium cyanescens, Normandina pulchella, Phyllopsora microdactyla, Physcia tribacioides, Pseudocyphellaria episticta* and *Sticta latifrons.* This last lichen is found on only the oldest trees of *Bracyglottis* and *Pittosporum fairchildii.* Young saplings of this latter plant tend to have a bark entirely free of lichens and it is only on the oldest specimens that *Sticta latifrons*, *Leptogium cyanescens* and *Clathroporina exocha* were seen. Such an association of lichens is common in northern coastal and lowland forest on the New mainland, especially where *Beilschmiedia tawa* is common. The most common lichen lowland forest interiors in northern New Zealand, *Pseudocyphellaria dissimilis*, is altogether from the Three Kings flora.

DISCUSSION

Of the 169 lichens recorded in this paper, 35% are widespread cosmopolitan species of a temperate or "oceanic" character (biogeographical terminology follows Galloway 1979, 1985), many producing readily dispersed diaspores such as soredia or isidia [e.g., *Candelaria concolor, Heterodermia leucomelos* ssp. *boryi, H.speciosa, Normandina pulchella, Pseudocyphellaria aurata, Teloschistes flavicans*], while others are consistently fertile and lack vegetative diaspores [e.g., *Lecanora atra, L.campestris* (see Brodo 1984), *Leptogium azureum, Thelotrema lepadium*]. Species endemic to the New Zealand region account for 20% of the lichens recorded, and a similar proportion (17%), including most of the species of *Xanthoparmelia*, have an Australasian affinity.

Pantropical taxa comprise *c.* 13% of the Three Kings lichens, prominent members of this element being *Coccocarpia palmicola, Hypotrachyna formosana, Pannaria fulvescens* and several species of *Parmotrema*, including the pantropical weedy species *P.cristiferum* and *P.tinctorum* (Hale 1965, Krog & Swinscow 1981). Many taxa in this element produce vegetative diaspores and are only rarely fertile.

Austral species in the Three Kings flora (7%), demonstrating a southern, circumpolar distribution (see Galloway 1979, 1985; Jørgensen 1983) include *Brigantiaea chrysosticta* (saxicolous in the Three Kings), *Cladonia capitellata, Leioderma pycnophorum* and *Stereocaulon corticatulum*, and ally the Three Kings lichens with

other southern Pacific lichen floras as well as with those of cool-temperate South America, and the islands Juan Fernandez (Zahlbruckner 1924, 1926) and Tristan da Cunha (Jørgensen 1977, 1979, 1983). Palaeotropical taxa, which include *Peltigera dolichorhiza, Cladina confusa, Pseudocyphellaria poculifera* and *Ramalina celastri*, comprise 5% of the Three Kings lichen flora and show distinct relationships with the lichen floras of north-eastern Australia, Lord Howe Island and New Caledonia (Smith 1922). *Erioderma sorediatum*, a presumed palaeotropical lichen first described from the Three Kings (Galloway & Jørgensen 1975), is now known from the Phillipines, India, Central America, the Caribbean and, very rarely, from North America (Maass 1983). A small number of species (3%) are part of the Western Pacific element and include *Heterodermia japonica* and *Peltigera nana*.

Because of the relative dryness of the island's climate, truly permanently humid habitats are lacking and hence a large number of genera and species common on the New Zealand mainland are absent from the Three Kings flora, especially taxa in such southern genera as *Nephroma, Menegazzia, Pannoparmelia, Pseudocyphellaria, Siphula* and *Sphaerophorus*. Genera not found on the Three Kings include: *Anzia* (the tropical *A.madagascarensis* is known from sites close by in Northland), *Baeomyces, Cetrelia, Chiodecton, Dendriscocaulon, Glyphis, Heterodea, Hypogymnia, Laurera, Lobaria, Lopadium, Ocellularia, Parmelina, Physma, Porina, Sarcographa, Thysanothecium* and *Trypethelium*, many of which have pantropical, palaeotropical or Western Pacific species reaching into New Zealand including several northern off-shore islands south of the Three Kings.

The characteristic local endemic component of the phanerogamic flora is not matched in the lichen flora to any extent, though of the Three Kings collections of *Neofuscelia pulla* Esslinger (1977) noted "... eight specimens collected from various localities on Three Kings belong to the stenosporic acid race but none contained the usual trace of divaricatic acid. Instead, each specimen contained a small or trace amount of perlatolic acid, with the stenosporic acid. These were the only specimens of *Parmelia pulla* found to contain perlatolic acid. The Three Kings race is apparently very localised. It is interesting to note that although this localised range is undoubtedly monophyletic, it exhibits much of the total range of morphological variation of *P.pulla* as a whole". Possibly the microlichens yet to be fully determined may disclose some taxa endemic to the Three Kings, but on present evidence the degree of endemism (at the species level) is of the order of 1% or less.

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GEOLOGY OF THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

BRUCE W. HAYWARD AND P.R. MOORE

NEW ZEALAND GEOLOGICAL SURVEY, LOWER HUTT

Abstract. Three Kings Islands are composed of hydrothermally altered submarine basalt flows and acidic tuff and breccia, represented by spilite and keratophyre (Three Kings Volcanics — new formation), together with closely associated and locally interbedded greywacke (Tokerau Formation). These rocks have been intruded by basaltic dikes and rare sills. The volcanics and associated sedimentary rocks are probably of Cretaceous age, possibly early Cretaceous.

The time of origin of the islands themselves is unknown but they are unlikely to have been joined to mainland New Zealand within the last few million years. The presence of high-level Quaternary terraces preserved on the islands indicates that the area is currently being uplifted.

The Three Kings Islands are situated about 50 km north-west of Cape Reinga, off the northern tip of New Zealand (Fig.1). The group consists of one large island (Great Island), three intermediate-sized islands (West, South West and North East Islands) and a chain of small, high-rising rocks (Princes Islands) (Figs.1,2).

The isolation of the group, the precipitous cliffs and characteristic high seas and strong currents in the area have prevented any previous attempts at comprehensive geological mapping. However, there have been several limited studies, mainly on the geology of Great I. Fraser (1929) noted that Great I was composed of greywacke, but it was Bartrum (1936a, b) who undertook the first geological research, during the *Will Watch* expedition of 1934. He spent one day around North West Bay and Castaway Valley, and collected samples of a pillowed spilite, an "albite porphyry", and a quartz keratophyre, all of which overlay "greywacke basement" near Cave Landing. His detailed petrographic studies of these samples resulted in the first recognition of spilites in New Zealand (Bartrum 1936b). The *Will Watch* expedition could not land on any other islands, and Bartrum had to be content with speculating on their composition from boat-based observations. His incorrect identification of greywacke forming West and South West Is illustrates the difficulty in distinguishing some lithologies from a distance. Thirteen years later, Buddle (1948) landed on South West I and Princes Is, and brought back three rock samples which Bartrum (1948) identified as quartz andesites.

In 1951 Battey (1951) spent 5 days on Great I and produced a preliminary geological map based primarily on cliff-top and inland exposures. His map is basically correct, but his inability to see the well-exposed geology in the encircling cliffs through

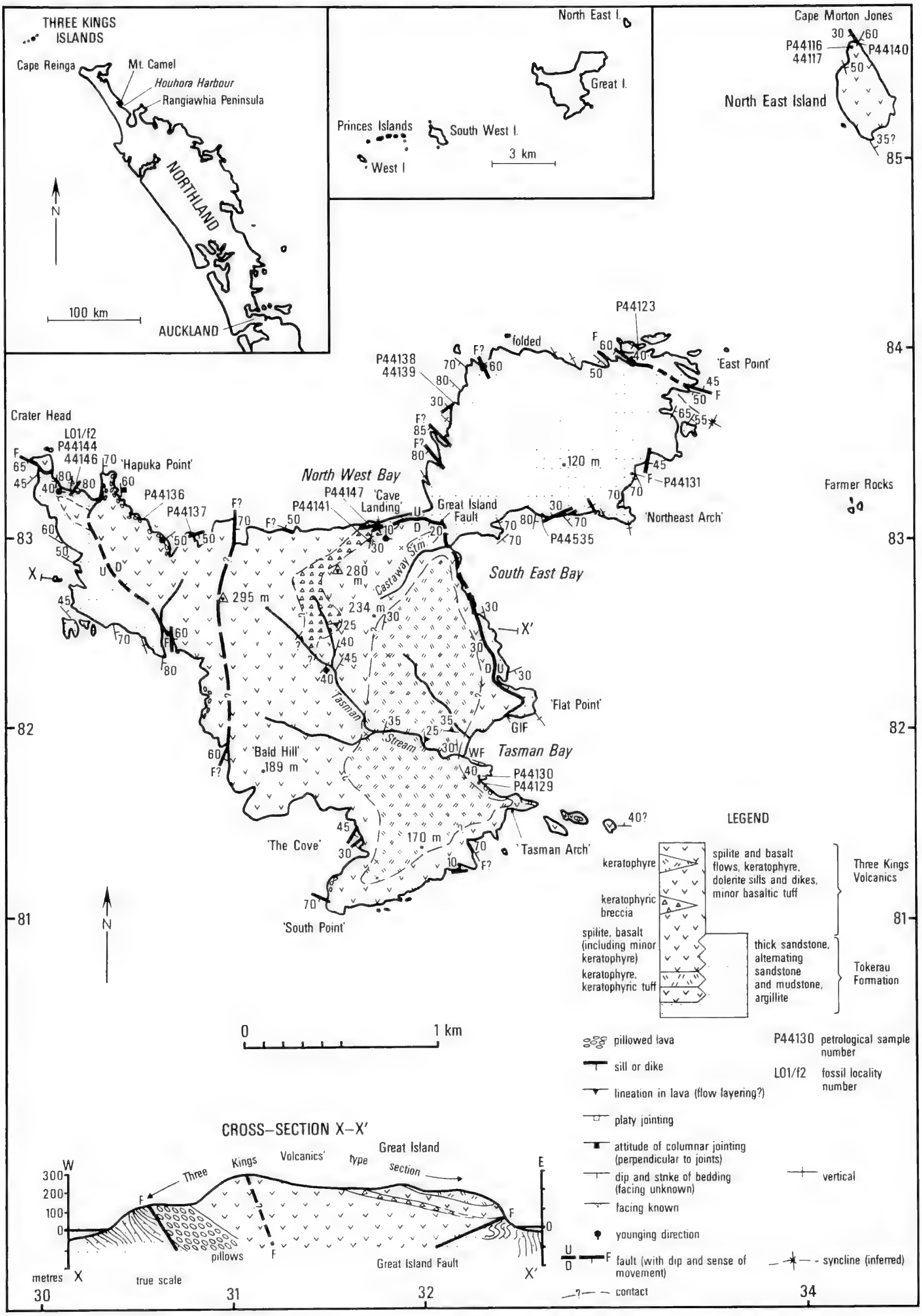

Fig. 1. Inset. Location of Three Kings Is off northern New Zealand. Geological map of Great and North East Is, and cross section through Great I.

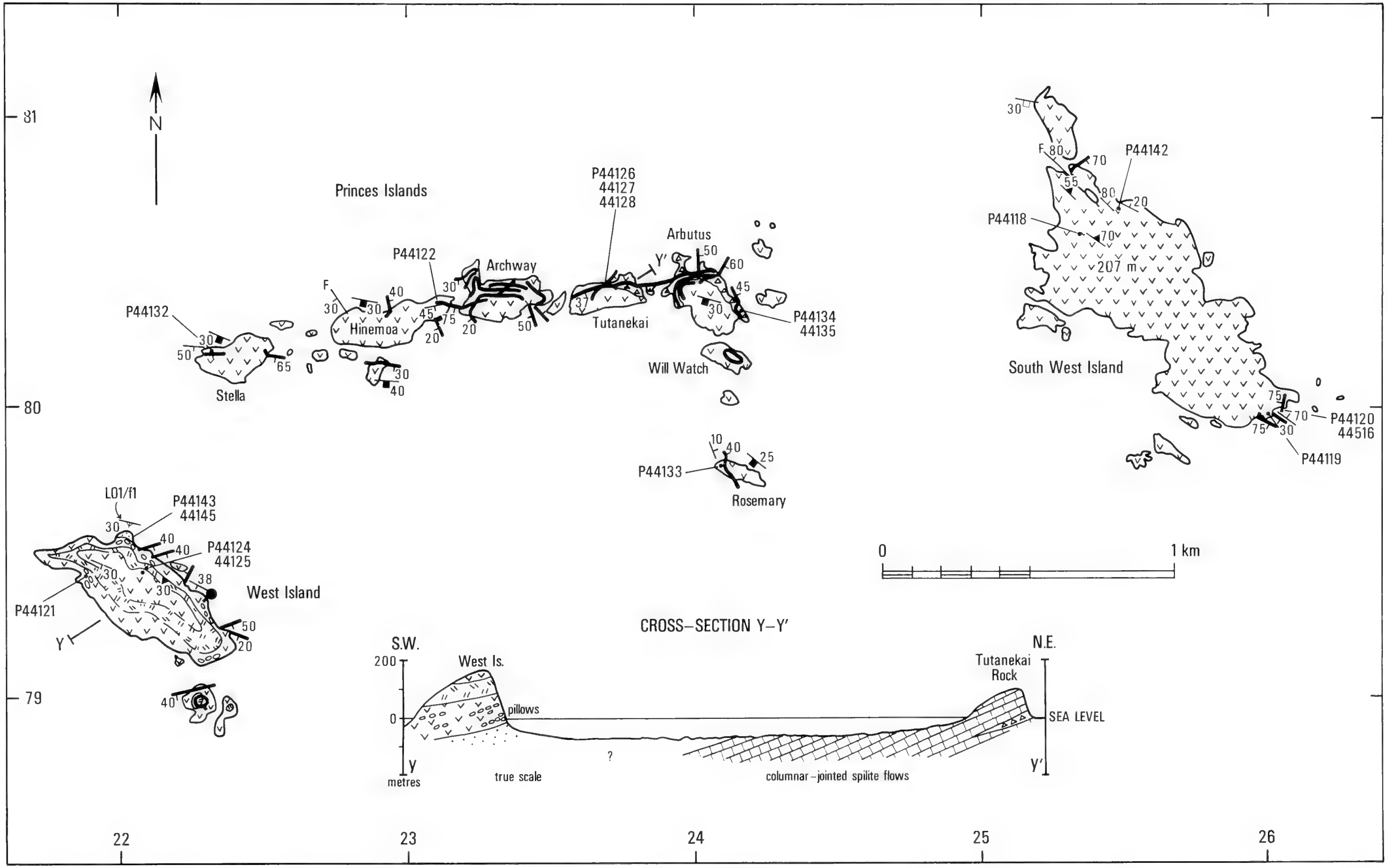

Fig. 2. Geological map of South West, West and the Princes Is, Three Kings Group, and cross section through West and the Princes Is. See Fig. 1 for legend.

the lack of a dinghy, prevented him from realising that the greywacke in the east was faulted against the spilites and keratophyres, rather than overlying them as he postulated. Battey (1954, 1955, 1956) discussed the petrography, petrochemistry and petrogenesis of these Great I spilites and keratophyres, together with similar rocks from Mt Camel and Rangiawhia Peninsula in northern North Auckland.

The other work relevant to the geology of the Three Kings is that of Summerhayes (1969) who produced a geological map of the seafloor in the region, based on dredged rock samples. In the vicinity of the Three Kings, he found the rock suite to be virtually identical to that on the islands themselves.

The authors undertook detailed mapping of the islands during an 8 day visit by the Offshore Islands Research Group in November-December 1983. This was made possible by an exceptionally calm period of weather, and the use of a 5 m rubber dinghy and a 4 m aluminium dinghy. The cliffs of North East, West and Princes Is, and of the north and east coasts of Great I, were examined closely but a shortage of time prevented detailed work around the south and west coasts of Great I or a circumnavigation of South West I. Mapping of inland parts of Great I was considerably hindered by the presently dense scrub cover. Petrography of the Three Kings rocks collected is discussed by Challis (1987 this volume).

STRATIGRAPHY

Tokerau Formation Hay 1975

Sedimentary rocks on the Three Kings include indurated thick-bedded sandstone, alternating sandstone and mudstone, laminated mudstone, and minor conglomerate, here referred to collectively as "greywacke". The northeastern part of Great I is almost entirely composed of greywacke, primarily a sandstone-dominated alternating sequence (Fig.3). Alternating beds also form part of the northwest end of Great I. Elsewhere on the Three Kings, sedimentary rocks are largely restricted to small outcrops of thin-bedded sandstone and mudstone or laminated calcareous mudstone interbedded with volcanics.

Around the north side of South East Bay, the greywacke sequence consists of thick-bedded sandstone with minor mudstone, centimetre-bedded alternating strata (sandstone : mudstone ratio 1:1 to 4:1 or higher), and some mudstone-dominated zones. The rocks are mostly strongly disrupted with pull-apart of sandstones, complex folding, and sheared argillite beds. In places, however, parallel and cross-lamination are seen in sandstone beds. Calcite veins are common locally.

At the northwest end of Great I, between Crater Head and "Hapuka Point", alternating beds (mostly cm-bedded) are particularly well-preserved and a eastward younging direction was determined from sedimentary structures. Included in this sequence is a 1 m thick tuffaceous? bed, concretionary mudstone, and a 6-8 m thick

Fig. 3. Indurated, bedded sandstone of Tokerau Formation in the shore platform near East Point, Great I.

pebble conglomerate (P44146; P numbers refer to samples in the New Zealand Geological Survey petrology collection), composed mainly of concretions and pebbles (mostly < 5mm) of siltstone, sandstone, chert, and keratophyre.

The only other place where the alternating facies is particularly well-preserved is at the north end of West I. Strata here consist of cm-bedded alternating fine to medium grained sandstone and grey mudstone (sandstone : mudstone ratio about 1:1 to 1:2) with a few small calcareous concretions and hard concretionary beds. Sandstones (lithic feldsarenite, P44145) are mostly 1-5 cm thick, but up to 10 cm, graded, and parallel to cross-laminated. Ripple lamination indicates flow of paleocurrents towards the east or NE, assuming a simple rotation of beds. Sole marks include small load casts and scour structures, and some sandstones are noticeably channelised. Mudstone beds have a blocky-cuboidal fracture and contain common trace fossils, although no cross-cutting burrows were seen.

Apart from minor intraformational slumping and numerous small-scale faults, alternating strata at this locality show remarkably little deformation, especially considering the close proximity to overlying pillow lava. This suggests that the sediments were moderately well compacted prior to burial beneath the lava flow.

"Laminated mudstone" interbedded with volcanic rocks, notably in Tasman Valley, at Cape Moreton Jones, and at the southern end of the South West I (P44516), consists mainly of mudstone-dominated, thin to very thin-bedded alternating sandstone and dark grey mudstone. At some localities, sandstone beds are up to 3 cm thick, graded and parallel laminated. Sandstone : mudstone ratio varies from about 1:4 to 1:6 or greater. As in the case of the alternating beds at West I, many of the laminated mudstone units are surprisingly little deformed, and must have been compacted prior to the extrusion of basic lava flows.

Relationship between sedimentary and volcanic rocks

There are several localities where relationships between greywacke and acidic and basic volcanic rocks are well exposed. The most important of these are Cape Moreton Jones (North East I), the cliff face at North West Bay below Three Kings Light, and at the southern end of South West I (Fig.4). At the northern tip of North East I, steeply dipping laminated sandstone and mudstone is conformably overlain by keratophyre,

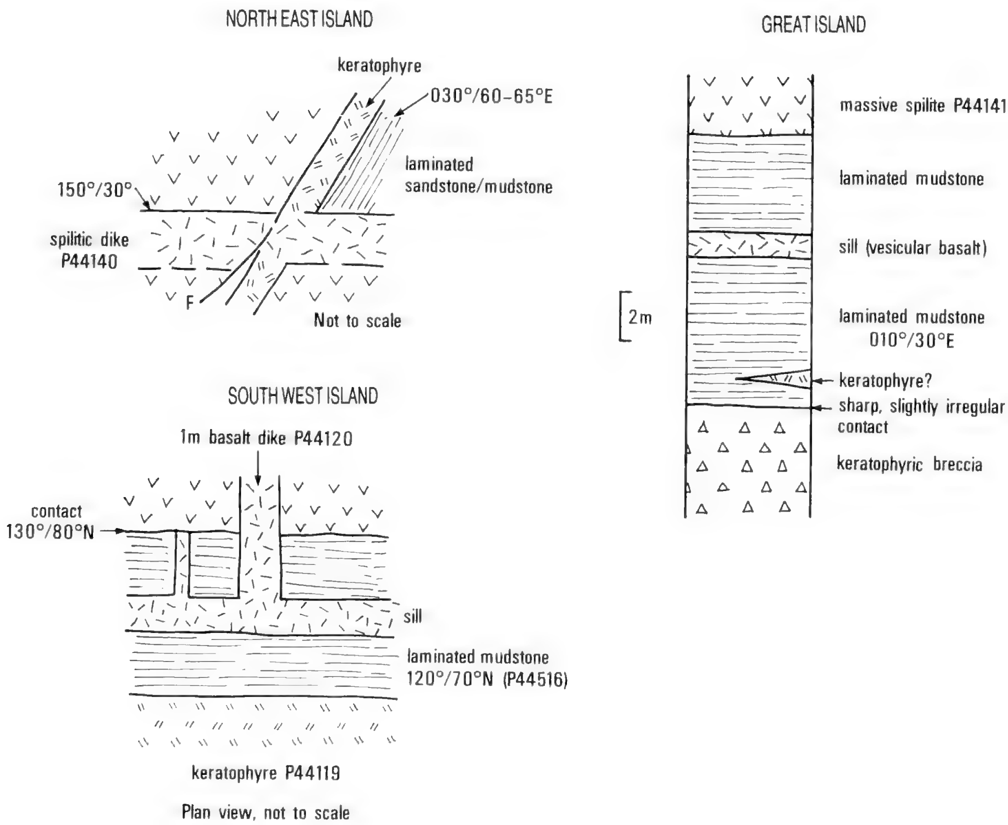

Fig. 4. Detailed relationships between sedimentary and volcanic rocks (based on field sketches). Top left. Northern tip of North East I. Right. Cliff face above North West Bay, Great I. Bottom left. Southern end of South West I.

and both are intersected by a later basic dike (Fig.4). Above North West Bay, on Great I, laminated mudstone overlies keratophyric breccia with a sharp sedimentary contact, and is in turn conformably overlain by a thick spilitic lava flow (Fig.4). Keratophyre may also be interbedded with the mudstone. At the southern end of South West I, laminated calcareous mudstone (P44516) is interbedded with amygdular keratophyre (P44119) and both are intersected by later basalt dikes (Fig.4). At the north end of West I, pillow lava has a sharp contact with underlying alternating beds, and shows local loading into the sediments.

Deposition of the greywacke is obviously closely related in time to emplacement of the keratophyric rocks and extrusion of the spilitic lava flows. Nowhere were dikes of keratophyre found cutting the sediments, although the presence of blocks of argillite up to 1.5 m diameter in keratophyric breccia at North West Bay (below, Fig.4) indicates that greywacke was locally involved in eruption/emplacement of acidic rocks.

Three Kings Volcanics new formation

TYPE SECTION. Cliffs of North West Bay, Great I, from the western base of "Hapuka Point" (L01/303832) to the top of the cliff just west of the saddle (L01/321831) separating North West and South East Bays (Fig.1 section X-X′, Fig.5).

DISTRIBUTION. Three Kings Volcanics are the dominant rocks on the Three Kings Is forming North East, South West and Princes Is, most of West I and the major, central part of Great I (Figs.1,2).

DESCRIPTION. These rocks consist of altered basaltic volcanics (dominantly spilite) and minor altered, interbedded rhyolitic tuff, breccias and possible flows (all keratophyre) intruded by numerous, mostly less altered, basaltic dikes. The majority of the volcanics are sheet-like flows (each 10-200 m thick), with pillow structure well developed in some of the basaltic units and sedimentary layering or flow-banding in some of the rhyolitic units. Thin units of obvious breccia and altered tuff are present locally.

THICKNESS. The sequence at the type section is 750 m thick, but a far greater total thickness is probable.

RELATIONSHIP TO OTHER ROCKS. Three Kings Volcanics are faulted against Tokerau Formation sedimentary rocks on eastern and north western Great I but are seen to conformably overlie Tokerau Formation at Hapuka Point, Great I and the northeastern tip of West I. Thin units (1-10 m thick) of mudstone are sporadically interbedded within the Three Kings Volcanics sequence, especially in Tasman Valley and Tasman Bay on Great I. It is apparent that Three Kings Volcanics and Tokerau Formation are partly contemporaneous seafloor deposits.

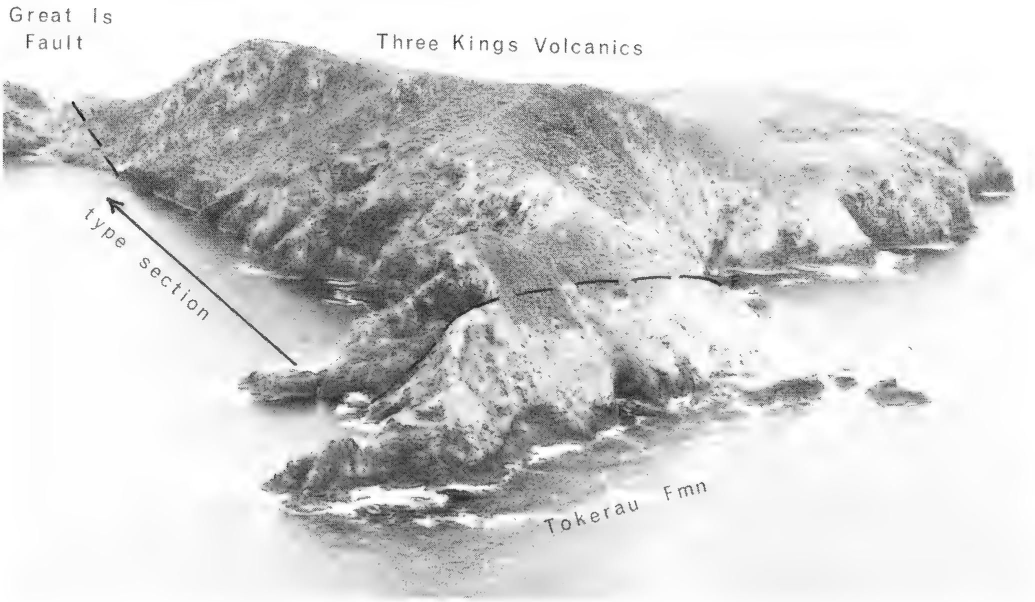

Fig. 5. Oblique aerial view of Great I from the north east. Crater Head (foreground) is composed of Tokerau Formation "greywacke" overlain and faulted against spilite pillow lavas at the base of the Three Kings Volcanics' type section. At the east end of North West Bay (far left) the spilites and keratophyres of Three Kings Volcanics are separated from further Tokerau Formation sediments by Great Island Fault.

Photo by Lloyd Homer.

Volcanics of basaltic parentage

The bulk of Three Kings Volcanics are medium to dark grey, massive, platy- or columnar-jointed, vesicular and in places, pillowed, lava flows originally of basaltic composition. Most have been altered to spilite (see Challis this volume). Thin veins of quartz and calcite are locally common and pods (up to 0.3 m across) of green, crystalline epidote occur within basic flows at Cape Morton Jones, north end of South West I and on Tutanekai Rock.

North East I is composed predominantly of featureless fine-grained spilite. At the northern end these lavas contain lenses (up to 1 m thick) of light-coloured keratophyre, a 1.5 m thick packet of Tokerau Formation sediments, and irregular pods of coarse-grained basalt.

The sequence of basaltic volcanics on Great I is best exposed in the type section, along the southwest coast and in Tasman Valley. The lower part, exposed around Hapuka Point, consists of ca. 200 m of pillowed spilite conformably overlying and also faulted against Tokerau Formation (Fig.5). The pillows are mostly elongate, up to 1 m

diameter, and their convex upper surfaces confirm an easterly younging direction. The presence of several, more massive tongues of spilite within this pillowed unit indicate that it is composed of a number of lava flow pulses. This is the "spilitic pillow lava" exposure studied in 1935 by Bartrum (1936a, b).

The pillow lavas are conformably overlain by ca. 450 m of virtually featureless, dark grey spilite that is cut by prominent, NW-striking fractures, and possesses occasional epidote pods and quartz veining. The sequence above this includes two thick units of keratophyric breccia and tuff, separated by ca. 70 m of vesicular and partly platy-jointed spilite. Within this spilite are several thin horizons of laminated mudstone.

South West I consists predominantly of massive, grey, basaltic lava with small areas (such as the northern tip) that are structurally complex and contain slivers of intensely altered, calcite-veined spilite interspersed with massive vesicular spilite and fine-grained less altered spilite.

The Princes Is consists of a ca. 350 m thick sequence of east-west striking, columnar-jointed, basic flows that appear to project eastwards into the west side of South West I (Fig.2, 6). Each flow is 15-30 m thick and separated from adjacent flows

Fig.6. Oblique aerial view of most of the Princes Is and South West I (top left) from the north west. These islands are mostly composed of columnar-joined, spilite flows that dip to the south (right) and are intruded by numerous basalt dikes that have been picked out by erosion. Photo by Lloyd Homer.

by 0.5-1 m thick zones of brecciated spilite. The sequence overlies a wedge of keratophyric breccia (Fig. 2 Y-Y′, 7). In the upper part of the Princes Is sequence on Rosemary Rock, the lava flows are partly pillowed and interbedded with tuff.

On West I, the Three Kings Volcanics are divided into three units (Fig.7). The ca. 70 m thick lower unit of massive and pillowed olivine basalt and mirror tuff conformably overlies Tokerau Formation sediments. Packets of pillows within this unit indicate several pulses of lava flow. The convex upper surface and draped lower surface of many of the pillows (Fig.8) show that the sequence is not overturned. This unit is separated from the upper spilite by 40-60 m of keratophyre. The upper, 60 m thick olivine spilite is not usually pillowed but locally platy-jointed and often vesicular.

Volcanics of rhyolitic parentage

A small portion of Three Kings Volcanics consists of orange or speckled grey-white, massive or layered, fine to coarsely crystalline, breccia and ash flows or tuffs, originally of rhyolitic composition. These have been altered to highly quartzose

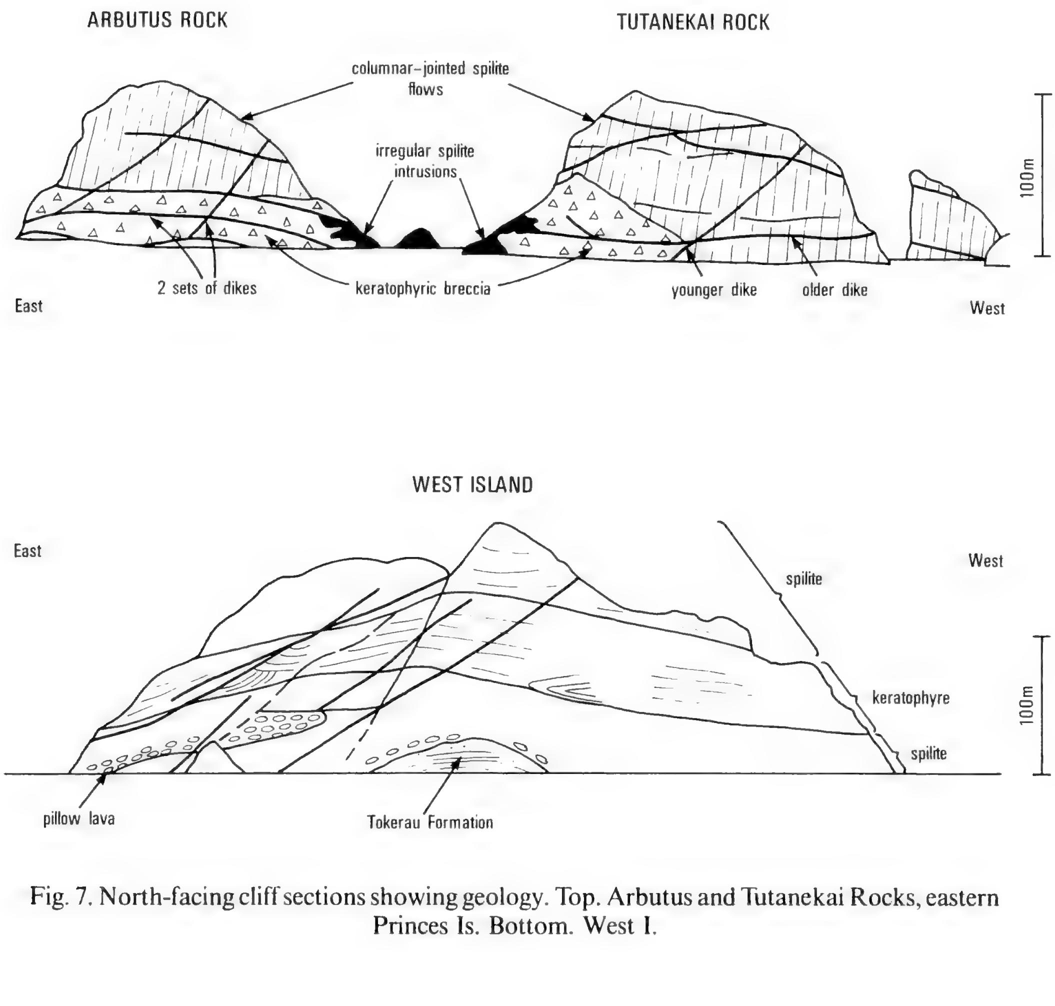

Fig. 7. North-facing cliff sections showing geology. Top. Arbutus and Tutanekai Rocks, eastern Princes Is. Bottom. West I.

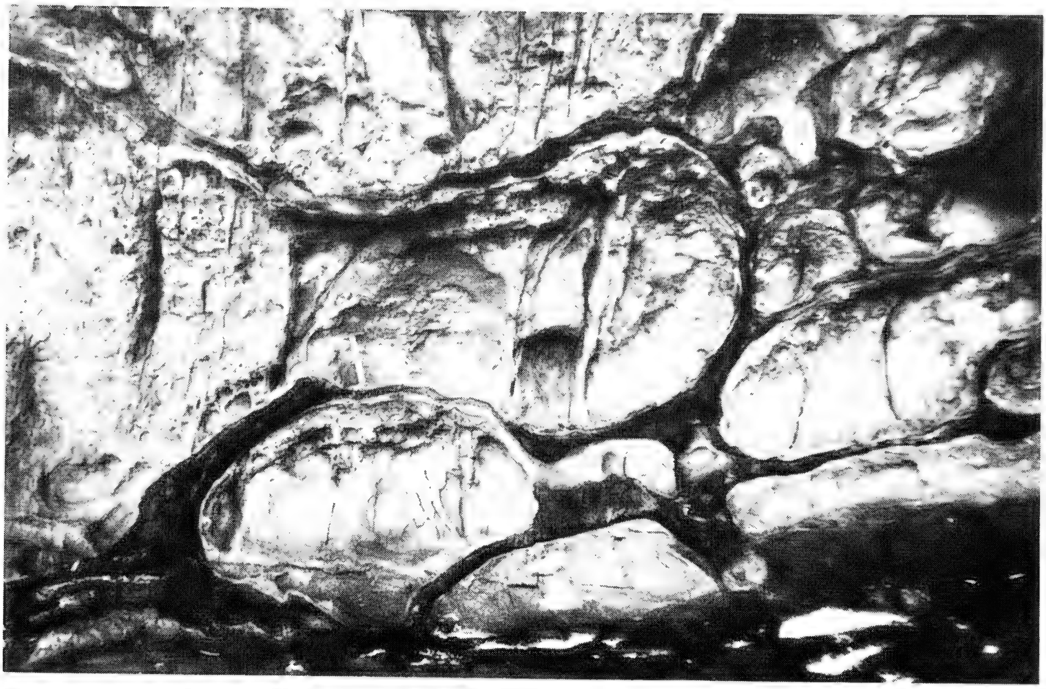

Fig. 8. Spilitic pillow lavas (Three Kings Volcanics) exposed in the cliffs on the east side of West I. Hammer 35 cm long.

keratophyres (see Challis this volume). They are distinguished in the field by their light colour, as well as layering or brecciated texture. The three main areas of outcrop of these rocks are on Great, eastern Princes, and West Is.

On Great I, two 30-100 m thick units of banded keratophyre and keratophyric breccia occur within the spilite sequence (Fig. 1, X-X′) exposed above North West Bay and in Tasman Valley. Breccia clasts are mostly 3-30 cm diameter and include minor spilite and mudstone fragments.

Near the foot of Tutanekai and Arbutus Rocks (eastern Princes Is), a wedge up to 40 m thick of orange-grey keratophyric breccia occurs conformably beneath columnar-jointed spilite flows and is intruded by irregular tongues of vesicular spilite (Fig.7). In the east, the breccia is fine-grained, green-coloured and monolithologic, whereas to the west, on Tutanekai, the clasts are mostly 3-10 cm diameter and include a mixture of fine and coarsely crystalline siliceous keratophyres together with less common spilite and mudstone.

On West I, a 40-60 m thick unit of banded, orange, pink, and speckled grey keratophyre occurs conformably within the spilite sequence (Fig. 7). The banding is produced by alternating layers of coarse and finely crystalline groundmass, often with the fine layers being more vesicular and weathered than the coarser.

Several thin lenses of keratophyre also occur within structurally complex spilites at Cape Morton Jones, North East I.

Intrusive rocks

All identified intrusive rocks on Three Kings Is are of basaltic parentage. These are most commonly parallel-sided, 0.3-6 m thick dikes with less frequent sills and irregularly-shaped intrusive bodies. The irregular intrusions are spilitised but the dikes and sills have undergone less alteration and mostly consist of coarse-grained basalt (see Challis this volume).

Scattered dikes intrude spilite, keratophyre, and Tokerau formation sediments on North East, South West and Great Is, but the greatest concentration of intrusions is on Princes and West Is. At the east end of Tutanekai Rock, three phases of intrusion are identifiable (Fig.7). The spilite flows and keratophyric breccia sequence is intruded by irregular tongues of vesicular spilite which are cut by a later 2 m thick, oligoclase basalt dike (090/37°S). The youngest intrusion, cutting all these rocks, is a 4 m thick coarse-grained olivine basalt dike (020/35°E).

On Tutanekai and adjacent Arbutus Rock, two sets of dikes intrude the sequence (Figs. 2, 7): an older, low-angle set, subparallel to the spilite flows (080-100/14-40°S) and a younger, steeper set (180-020/35-60°E). Two sets of low and steep angle dikes are also present on Archway and Hinemoa Rocks. On West I, one set of dikes is dominant. These dip at 20-40° to the south-east (Figs. 2, 7).

Very few sills were identified on the Three Kings Is. However, they do occur within Tokerau Formation sediments above North West Bay, between spilite flows on Stella Rock, and at the south end of South West I (Fig.4).

STRUCTURE

TOKERAU FORMATION

On Great I, bedding in the greywacke has a strong N to NW trend. The rocks are tightly folded in places and near 'East Point' strata are probably folded into a SE-plunging syncline. Faulting is widespread, and the shape of the coastline appears to be controlled partly by steep NW-trending faults. Near "Hapuka Point" alternating beds face eastward and are locally overturned.

The degree of deformation is variable; on eastern Great I, bedding is sheared and locally strongly disrupted in contrast to the relatively undeformed sequences at the western end, and on West I.

THREE KINGS VOLCANICS

On Great I, the Three Kings Volcanics sequence is structurally simple, mostly dipping 35-60° to the east or south-east (Fig. 1, X-X′). Approaching the Great Island Fault, the sequence is folded into a gentle syncline.

On West and Princes Is, the Three Kings Volcanics sequence has a consistent 30-50° tilt to the southwest (Fig. 2, Y-Y′). The seafloor geology between West I and the Princes Is is unknown, but if no major fault intervenes, then the spilite-keratophyre sequence on West I would lie ca. 200 m stratigraphically above the volcanics of the Princes Is. The columnar-jointed spilite flows of the Princes Is sequence appear to project into the west side of South West I. The bulk of South West I, however, consists of steeply (55-80°), north-east dipping spilite, and a major structural break probably occurs within the western part of South West I.

GREAT ISLAND FAULT (Fig.3)

In North West Bay, sheared greywacke is faulted against overlying green-grey, fine-grained spilite, and the fault contact dips about 20°SW. The fault is largely obscured to the west, but can be traced along the west side of South East Bay where it appears to dip about 30° W.

This fault is clearly a major feature as it truncates the eastward-dipping volcanic succession forming much of western Great I and probably has a vertical displacement in excess of 500 m (cross-section Fig. 1, X-X′). Whether it represents a low-angle normal fault or thrust fault is uncertain, but it is interpreted here as a normal fault.

QUATERNARY TERRACES

A number of flat or gently sloping terraces are preserved on the Three Kings Islands. The lowest, 70 m a.s.l., forms "Flat Point" between South East and Tasman Bays, on Great I. The largest and most obvious covers most (50 ha) of the north-east portion of Great I (Fig.9). This terrace is at an altitude of 80-110 m and slopes gently to the east. The gently sloping, flat top of nearby North East I is the same height and may be a remnant of the same terrace level. Also at the same elevation (90-110 m) are the coincident crests of the five largest rocks in the Princes Is group (Fig.6).

A slightly higher terrace, at 120-140 m, is present at the southern end of South West I. Flat-topped, coincident ridge crests at higher elevations on Great I are possibly the remnants of a number of even higher terrace levels at ca. 160-180 m, 200-210 m, and 270-280 m (Fig.9).

These terraces were probably intertidal or shallow subtidal marine platforms cut during successive interglacial sealevel stands during the Quarternary (last 1.6 M years) and have been preserved by uplift of the islands. They provide convincing evidence that the whole area has been slowly rising for some considerable time.

Fig. 9. Oblique aerial view from the south west over eastern Great I and North East I (distance). Distinct Quaternary terraces are recognisable at 70 m on "Flat Point" (t_1), at 80-110 m on north-east Great I and North East I (t_2) and flat-topped ridge crests (possibly remnant terraces) at 160-180 m (t_3), 200-210 m (t_4) and 270-280 m (t_5).
Photo by Lloyd Homer.

DISCUSSION

Age and correlation

There is no direct evidence for the age of either the Tokerau Formation or Three Kings Volcanics on the Three Kings Is. Two Tokerau Formation mudstones (L01/f1, f2, Figs.1,2) processed for dinoflagellates, proved non-fossiliferous (G.J. Wilson, pers. comm.).

Throughout Northland, spilite and basalt similar to that on the Three Kings has been assigned to three groups — Whangakea Volcanics, Tangihua Volcanics and Houhora Volcanics. Sedimentary units interbedded or associated with all of these have confirmed Cretaceous fossil ages. Petrographically, the spilites and basalts of Three Kings Volcanics are indistinguishable from those of the Whangakea Volcanics at nearby Cape Reinga and Cape Maria van Dieman (see Challis this volume), which contain intercalated sediments with late Cretaceous foraminifera (Hornibrook & Hay

1978). Whangakea (and Tangihua) Volcanics do not have associated rhyolites or keratophyres, however, and the intercalated sediments are mostly multi-coloured, sheared mudstones, quite different lithologically from Tokerau sediments of the Three Kings.

The spilite — keratophyre — greywacke (Tokerau Formation) association of the Three Kings Is compares most closely with the Houhora Volcanic Group which outcrops on the adjacent mainland around Mt Camel (Hay 1981) and Rangiawhia Peninsula (Hay 1975). The Three Kings basalts and spilites are far less altered than those at Mt Camel and Rangiawhia (see Challis this volume), but all may have been lithologically quite similar originally. At Mt Camel, specimens of *Inoceramus* in Tokerau Formation sediments give a Urutawan or Motuan age (= Albian, late early Cretaceous; Hay 1981). By correlation, an early Cretaceous age is possible for the Three Kings rocks.

The Cretaceous Tangihua and Whangakea Volcanics are variously interpreted as having formed at an ocean ridge, as seamounts, or a combination of these (e.g. Farquhar 1969, Brothers 1974, Ballance & Sporli 1979, Brothers 1983). They mostly occur in discrete fault-bounded blocks that most recent workers have suggested were obducted into Northland from the northeast during the late Oligocene (Brothers 1974, Ballance & Sporli 1979, Brothers & Delaloye 1982). The question of whether Three Kings Volcanics and Houhora Volcanics at Mt Camel and Rangiawhia Peninsula were also emplaced by obduction cannot be answered at the present time. We have no evidence to suggest that they are anything other than in place.

Seafloor rock samples show that greywacke, basic volcanics and rare keratophyre are the dominant rock suite around the Three Kings Is, and extend 30 km to the northeast over Bowling Bank and 30 km to the northwest over van Diemen Bank (Summerhayes 1969). Most of the ridge between Cape Reinga and the Three Kings is composed of basalt and other igneous rocks which were interpreted by Summerhayes (1969) as belonging to Whangakea Volcanics separated from the keratophyres and spilites of the Three Kings by a fault located 10 km southeast of the Three Kings Is.

Geological and island history

About 100-60 million years ago (late early to late Cretaceous), basaltic lava flows and tuffs, and rhyolitic pyroclastic sediments and flows (Three Kings Volcanics) were erupted in the Three Kings region. They accumulated on the seafloor together with mud and sand of the Tokerau Formation, and appear to have built up a considerable volcanic pile. There is no strong evidence for a subaerial or shallow water depositional environment. Rhyolitic pyroclastic flows are erupted from subaerial or shallow water vents but often flow into deep water where they are deposited as laminated tuffs, similar to the Three Kings keratophyres (Yamada 1984). Whether these volcanics were erupted from an ocean ridge or seamount, is purely conjecture.

As the sequence built up the Three Kings were intruded by dikes and rare sills of basalt. Some of these dikes were probably feeders to lava flows being erupted on the seafloor above. Some time after eruption, the flows, dikes, tuffs, and breccias were

hydrothermally metamorphosed to spilite and keratophyre. Hydrothermal metamorphism may have been related to a large intrusive body of magma nearby.

With increasing depth of burial beneath a growing pile of flows and sediments, Tokerau Formation rocks were indurated. A major phase of volcanism around northern New Zealand, and probably also the Three Kings area, appears to have ceased about the end of the Cretaceous.

No evidence is available concerning the pre-Quarternary Cenozoic history of the Three Kings. Presumably the Three Kings' rocks remained deeply buried and were deformed and faulted by deep-seated earth movements. At some stage they were gradually uplifted and the overlying and surrounding rocks eroded off.

When the Three Kings area first became land is unknown. The bathymetry of the surrounding sea and the evidence of considerable Pleistocene uplift indicates that the Three Kings landmass has probably not been connected by land to Northland at any time during the Quaternary (last 1.6 M years), nor probably for a long time prior to that. The sea gap was possibly narrowed to ca. 25 km during several glacial periods of lowered sea level (most recently only 18,000 years ago). At this time, when sea level was 100-120 m below present, all the islands of the present Three Kings group would have been joined together.

The Three Kings owe their shape to erosional processes that have occurred in the last million or so years as sea levels have fluctuated up and down during alternating glacial and interglacial periods. During this time the whole area has been slowly rising, so that extensive platforms carved out at intertidal or shallow subtidal depths during extended periods of high, interglacial sea level are now uplifted and recognisable on the islands as contiguous ridge crests and terraces. Terrestrial erosion has modified many of these uplifted marine platforms and carved out the stream valleys on Great Island. Most of the present seacliffs drop straight down into deep water and have been carved out by sea erosion during both high and lowered sealevels throughout the Quaternary.

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PETROGRAPHY OF IGNEOUS AND SEDIMENTARY ROCKS FROM THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. The igneous rocks described are spilite, olivine basalt, basaltic tuff, and keratophyre intruded by numerous dikes and sills of basaltic composition. Almost all keratophyres are shown to be hydrothermally altered rhyolitic tuffs and ash flows that have undergone potassium metasomatism. The spilites are also products of sodium metasomatism of original olivine basalt. The alteration to keratophyres and spilites was favoured by high permeability and porosity in the rhyolitic tuffs and highly vesicular and brecciated basalts.

Suggested correlation is with the Whangakea Volcanics of North Cape. Sedimentary rocks are iron-stained conglomerate, clay and chlorite cemented arenite, siltstone, and calcareous argillite. It is concluded that the Three Kings Islands were a group of Cretaceous volcanic islands or seamounts, with initial submarine, but later subaerial volcanism.

Previously published petrographic descriptions of Three Kings Islands rocks by Bartrum (1936a, b) and Battey (1955, 1956) dealt only with the igneous rocks. They described spilite, keratophyre, and a rock that Bartrum described as an "albite porphyry", but which re-examination shows to be a basic tuff. Five chemical analyses were published in four different papers; these are given here (Table 1) for convenient reference. In the present work, Bartrum's original analysed rocks (P23641, 23642, 23643) have been re-examined, and a further 27 igneous and 7 sedimentary rocks (collected by B.W. Hayward and P.R. Moore in 1983) are described. P numbers refer to samples in the petrological collection of New Zealand Geological Survey, Lower Hutt. The geology of the Three Kings Is is described in the preceding paper (Hayward & Moore 1987) which gives details of localities and features mentioned here.

IGNEOUS PETROGRAPHY (THREE KINGS VOLCANICS)

Spilite

By far the most abundant rock type on the Three Kings Is is a fine-grained, microporphyritic spilite, which is sometimes found as pillow lavas (P44136), but more commonly as massive flows (P44117, 44118, 44125, 44129, 44134, 44137 and 44141).

Table 1. Five chemical analyses* of Three Kings Islands rocks.

Weight %	1	2	3	4	5
SiO_2	75.10 †	63.58	59.94	70.26	54.87
TiO_2	0.22	0.99	2.54	0.68	2.02
Al_2O_3	12.84	13.42	12.81	12.58	14.98
Fe_2O_3	0.70	2.10	3.76	3.30	1.65
FeO	1.36	5.67	9.29	2.00	8.89
MgO	0.30	1.37	3.65	0.36	3.33
CaO	0.32	2.75	6.22	1.26	4.06
Na_2O	5.12	4.31	5.25	4.77	5.73
K_2O	2.39	2.93	0.18	2.88	1.13
H_2O+	0.95	1.85	2.33	0.97	2.39
H_2O	0.27	0.30	0.21	0.27	0.25
P_2O_5	0.04	0.35	0.36	0.52	0.47
CO_2	0.03	0.03	—	—	—
ZrO_2	0.01	0.01	—	—	—
S	0.06	0.02	0.12	—	—
Cl‡	0.02	trace	0.02	—	—
MnO	0.04	0.14	0.21	trace	0.04
NiO	—	0.01	0.02	—	—
BaO	0.05	0.05	trace	—	—
SrO	trace	0.01	—	—	—
Total	99.82	99.89	99.91	99.85	99.81

*1. Keratophyre, Great I, Three Kings Is (Bartrum 1936a, b).
2. Albitic porphyry (tuff), Great I, Three Kings Is (Bartrum 1936a, b).
3. Spilite, Great King I, Three Kings Is (Bartrum 1936a, b).
4. Dark-coloured keratophyre, summit of South West I, Three Kings Is (Battey 1955).
5. Spilite, cascade upper Tasman Stream, Great I, Three Kings Is (Battey 1956).

Analyst: Nos. 1-3 F.T. Seelye, 4&5 M.H. Battey.

† Weight %.
‡ Chlorine is almost certainly due to sea spray.

Many of the massive lavas are amygdaloidal, with amygdales infilled by quartz, calcite, chlorite, albite, and, rarely by K-feldspar or zeolites (P44125, 44129, 44130, 44134). The rocks are cut by veins of calcite and quartz or quartz and epidote; the latter may be up to 0.5 m in width (P44128).

Massive spilite is a dark grey, microporphyritic rock. Small, scarce phenocrysts of albite (An_{5-7}) and colourless augite are set in a microcrystalline groundmass of tiny, elongated laths of albite with abundant chlorite, granular epidote, magnetite, calcite and usually a little quartz. Apatite and sphene are constant accessories, and zircon occurs rarely. Texture is normally intersertal, but variolitic texture is well-developed in a few rocks (P44118, 44132) with spherules of radiating, fibrous albite containing tiny crystals of albite, epidote and magnetite at the centre. The albite phenocrysts range from less than 1 mm to over 3 mm in length and can be almost water-clear with fine albite twinning (P44122, 44137), or clouded by alteration products chlorite, epidote and sericite (P44117, 44125) and frequently twinned on the Carlsbad law. Highly

altered feldspar phenocrysts tend to occur in amygdaloidal rocks, and may be partly replaced by K-feldspar (P44118, 44125, 44129). Pyroxene phenocrysts are nearly always completely unaltered, even when the feldspar is quite indeterminable (P44117); the pyroxene is a colourless, or very faintly pink or brown augite.

Although the groundmass is usually holocrystalline, but very fine-grained, a few samples have a groundmass of partly devitrified glass containing highly acicular, feathery crystals of clinopyrozene and abundant skeletal magnetite (P44117, 44118). A variant of the microporphyritic spilites is a fine-grained, equigranular rock with intersertal texture (P44134) composed of elongated laths of albite and curved crystals of a brown and rather fibrous diopsidic augite. Interstices are filled with granular augite, chlorite, epidote, albite and magnetite. The rock is quite vesicular and vesicles are infilled by radiating aggregates of bright green and slightly pleochroic (green-gold) chlorite. Bartrum's analysed sample (Bartrum, 1936a, b, Table 1, No. 1) is a rock of this type and contains the rare mineral babingtonite (Battey 1954). This mineral is present in very small amounts in P44134.

Quartz is a constituent in vesicles of nearly all amygaloidal spilites and may also be present in significant amounts in the groundmass (P44125). In these rocks, K-feldspar partly replaces albite and pervades the groundmass adjacent to veins and vesicles.

Keratophyre

These rocks are light-coloured, grey or greenish-grey and sometimes iron-stained. Often amygdaloidal, they are interbedded with amygdaloidal spilite in at least two main layers on Great I. In the field, some of the keratophyres (P44135) are quite obviously breccias, whereas others (P44124, 44147) show what appears to be flow banding. Both Bartrum (1936b) and Battey (1955) had difficulty in deciding between a flow or pyroclastic origin for the Three Kings keratophyres, and Battey (op. cit.) noted the similarity of some of the rocks to ignimbrite. For the present study, large thin sections were used in order to get a better idea of the texture. In all but one case (P44147), the rocks are clearly of pyroclastic origin, either ignimbrites or ash showers, although some may be redeposited water laid tuffs. Although all the rocks contain abundant groundmass and amygdaloidal quartz, there is no phenocrystic quartz so that the term "quartz keratophyre" is not used (cf. Battey 1955).

Typical keratophyres (P44147, 44116, 44119, 44124) contain sparse phenocrysts of albite (An_7) sometimes bent or shattered and occasionally (P44116) forming aggregates, set in a microcrystalline groundmass of tiny albite laths, often bent and irregular in shape, with quartz, flakes of yellow-green chlorite, abundant granular epidote and scarce magnetite. Staining with sodium cobaltinitrite showed only slight replacement of plagioclase phenocrysts by K-feldspar, but in the more vesicular rocks (P44147, 44149, 44125) K-feldspar rims vugs and borders quartz veins. It is sporadically distributed in the groundmass near vugs and veins, but is not found in massive, non-vesicular keratophyre (P44146). Pyrite, sometimes in euhedra up to 1

mm is a scarce component; it is often altered to hematite which produces iron-staining in the rock (P44146). Vugs are infilled with feathery and comb-structured quartz with centres of calcite or chlorite and very occasionally albite or zeolite (gmelinite). Prehnite is sometimes plentiful in the groundmass and veins of keratophyre breccias (P44135). In rocks showing strong "flow banding" (P44124), the bands are defined by darker, chlorite-rich material. In thin section the chlorite can be seen to be replacing flattened lumps of pumice, and hydrothermal alternation of pumiceous glass to a chlorite of very similar optic properties has been described from Wairakei (Steiner 1977:p62). The "flow banding" appears to represent pumice-rich layers in a pyroclastic deposit, and the lumps of pumice themselves are randomly oriented in the layer. Some keratophyres (P44119) retain a shadowy vitroclastic texture with glass shards replaced by zeolite. Fragments of more basic tuff in P44116, 44124 and 44135, are very scarce components, and in P44116 there are a few fragments of siltstone. In one keratophyre (P44147) the albite phenocrysts are strongly oriented with long axes in the direction of "flow-banding", although lumps of randomly oriented, chloritised pumice are obvious in the darker beds; the feldspar orientation could be the result of ash flow.

Basalt (P44121)

This sample comes from a pillow lava (Hayward & Moore this volume Fig.8) forming the basal 70 m of the volcanic sequence on West Island. The basalt is a holocrystalline, fine-grained, non-vesicular rock composed largely of plagioclase feldspar (An_{57}) and augite. Augite forms about 30% of the rock and is accompanied by scarce phenocrysts of olivine, almost completely altered to talc and calcite. Magnetite is a plentiful accessory. The basalt shows little alteration overall; feldspar and augite are completely unaltered, and there is only a very little chlorite and epidote in interstices.

Dike rocks

Although basic dikes are seen to cut each other, and have been referred to an older and younger set, they are compositionally the same and in fact, the "younger" dikes may be more altered than the "older".

Basalt dikes

These are typically (P44143) dark-grey, fine-grained, microporphyritic rocks with small phenocrysts of plagioclase (An_{73-65}) and colourless augite in a holocrystalline, equigranular groundmass of plagioclase (An_{60}) and augite. There are rare pseudomorphs of montmorillonite-chlorite after olivine, a few small flakes of reddish-brown biotite, and plentiful magnetite. Larger feldspar phenocrysts are commonly altered to sericite and clinozoisite and there is a small amount of calcite in sparse vesicles and in the groundmass. Pyrite and rare chalcopyrite are also present. An unusual variant of the basalt dikes of South West I is P44120, a fine-grained holocrystalline rock which consists almost entirely of plagioclase (An_{73-65}) and magnetite. Texture is intersertal, grading to variolitic. There are scarce flakes of brown biotite, and chlorite closely associated with calcite forming large pseudomorphs after

olivine. Calcite is also found in small amounts throughout the rock. Tiny crystals of apatite are abundant, while strongly resorbed brown hornblende and highly chloritised pyroxene are scarce. Small patches of quartz are present in the groundmass.

Altered and spilitised basaltic dikes and sills

Most dikes show some degree of alteration. The least altered (P44126), from a 2 m thick dike on Tutanekai Rock, is a dark grey holocrystalline rock composed of small, scarce phenocrysts of augite rimmed by pink titan augite, in a groundmass of small augite crystals and laths of highly altered plagioclase. The plagioclase is diffusely zoned (An_{55-28}) with more calcic cores altered to sericite, chlorite, epidote and analcime. Interstitial chlorite is abundant, and there are rare chlorite and calcite pseudomorphs after olivine. Water clear albite forms small crystals and pools in the groundmass, and magnetite and pyrite are common accessories. A 4 m thick dike (P44127) cutting the one just described is slightly more altered and feldspar is completely albitised. Pyroxene phenocrysts and olivine psudomorphs are slightly larger and more abundant but otherwise the mineralogy and texture is very similar to the earlier dike. Staining revealed quite extensive replacement of albite phenocrysts by K-feldspar, but no alteration of the groundmass feldspar. Magnetite, pyrite and scarce chalcopyrite are also present. A sill (P44142) cutting spilite on South West I is very similar, but has phenocrysts of augite up to 10 mm in length.

A basic dike (P44140) cutting keratophyre on North East I is a highly porphyritic rock with altered feldspar phenocrysts up to 5 mm in length replaced by a mixture of sericite, epidote, analcime and chlorite. The original form of the crystals is sharply preserved against the groundmass of equigranular augite, altered plagiocase, water-clear albite and chlorite, epidote and magnetite.

On Great I, dikes of variolitic spilite are common.

Basaltic tuffs

Tuff (P44133) forms a layer between two spilite flows on Rosemary Rock and a very similar rock (P44525) is found interlayered with normal basalt pillow lava on West I. The tuffs are dark greenish grey rocks, mottled with irregular white patches of quartz and calcite, and bright green areas of chlorite and epidote. In thin section they are a highly brecciated, cryptocrystalline aggregate of chlorite, epidote, quartz, prehnite and zeolite (thomsonite), with fragments of basalt, spilite, dolerite, basaltic glass, and chloritised pumice. Amygdales are infilled with quartz and epidote, or occasionally with thomsonite. Glass shards replaced by prehnite give a vitroclastic texture to some areas of the rock. Staining reveals scarce K-feldspar in veins and patches. The "albite porphyry" described by Bartrum (1938b) appears on re-examination to be a basaltic tuff rather than a flow.

These rocks were interpreted as hyaloclasite in the field, but closer examination shows that although fragments of glassy, vesicular basaltic material predominates, and make up 70% of the sample from Rosemary Rock, the presence of fragments of

pumice, coarser-grained spilite and glass shards between the fragments shows that the rocks are tuffs. Random orientation of pumiceous and elongated rock fragments suggests an air fall or water laid origin rather than an ash flow. The comparatively rare mineral babingtonite, described by Battey (1954) from spilite on Great I is also present in the tuff (P44133).

SEDIMENTARY PETROGRAPHY (TOKERAU FORMATION)

Pebble conglomerate

This rock (P44146), found near Hapuka Point on Great I, is a dark coloured fine pebble conglomerate in which sub-rounded to well-rounded pebbles, averaging less than 1 cm in diameter, are set in a fine siltstone matrix. The pebbles are siltstone, sandstone, chert and minor keratophyre. The siltstone in pebbles is very fine-grained with abundant flakes of mica, randomly distributed throughout the rock, which is not schistose. The sandstone pebbles are a lithic arenite in which the rock fragments are of the same type as those found as pebbles. Pebbles of chert are very plentiful and are commonly fractured and crossed by veins of secondary quartz. Less plentiful are small, rather more angular pebbles of keratophyre, very similar to that now exposed higher in the sequence on Great I. The matrix is a very fine micaceous siltstone similar to that found as pebbles. All pebbles and mineral grains are coated by reddish-brown oxides. The sedimentary conglomerate pebbles are similar to rock types found in the Tokerau Formation, but in the sample examined there was no sign of basic igneous material.

Sandstone

The sandstones on Great I (P44123, 44131, 44139, 44144) and West I (P44145) are all medium to fine-grained, dark grey rocks. Narrow veins of calcite and quartz are common. In thin section, they are moderately sorted to well-sorted, clay and chlorite-cemented arenites, grading to lithic feldsarenites. Clay and silt size matrix, highly micaceous, make up less than 10% of the rock, except in shear zones and siltstone layers where it might comprise 40% of the rock. Quartz is by far the most abundant detrital mineral, and occurs as both angular and rounded individual grains, and as fragments of chert and quartzite. Detrital feldspar is next in abundance, with albite being the most common type and oligoclase, microcline, or microperthite present in most rocks. Epidote, sphene, magnetite, apatite, bleached brown biotite, muscovite and zircon are less common detritals. Rock fragments are, in order of abundance: fine-grained micaceous siltstone, fine-grained sandstone, chert, keratophyre, and spilite. The cement is a pale yellowish-green chlorite.

Siltstone

This is interbedded with sandstone in very finely bedded units on Great and West Is. Individual siltstone/sandstone bands may be only 2-3 mm thick and show fine current bedding (P44144), or slight contortion of the bedding, possibly due to penecontemporaneous slumping. The siltstone contains the same detrital minerals and

rock fragments as the sandstone, but more grains are angular and the proportion of fine clay size material is higher. Iron oxides and other opaque black materials are distributed as thin flakes throughout the sandstone and siltstone, and tend to concentrate on boundaries between layers.

Argillite

Argillite interbedded with spilite and keratophyres on South West I (P44516) is a dense, black, extremely hard rock, S.G. = 2.68. Slightly fissile, it breaks with a rough conchoidal fracture and has been hornfelsed by the overlying lavas and numerous dikes. Original bedding is possibly represented by very narrow 1-2 mm quartz rich layers. In thin section the rock is highly calcareous, with small pools and flakes of calcite forming approximately 20% of the rock. The main detrital mineral is quartz, which is present as sub-grounded grains with very diffuse and indistinct borders resulting from solution of quartz due to the high calcite content and thermal metamorphism. Rare feldspar grains are albite, and there are no identifiable rock fragments. Pyrite and iron oxides are plentiful and pyrite occasionally replaces microfauna, although (unidentifiable) foraminifera are more usually replaced by quartz in this rock. The extremely fine-grained groundmass is composed of chlorite, calcite, and micaceous clay. Abundant black flakes of organic material or iron oxides may define original bedding.

Conclusion

The sedimentary rocks are quartzose, relatively well-sorted, and the detrital minerals and rock fragments could all have been locally derived. The rarity of basic igneous material suggests that basaltic volcanism commenced after deposition of the bulk of the Tokerau Formation, although the common presence of keratophyre in the sandstone and pebble conglomerate points to an earlier episode of rhyolitic volcanism.

DISCUSSION

Formation of spilite and keratophyre

The Three Kings provide an unusually clear example of the formation of spilite and keratophyre by hydrothermal metamorphism of basic lavas and acid tuffs, the controlling factor in the alteration being permeability and porosity of vesicular lavas and tuffs. This process is best demonstrated on West I where massive, non-vesicular pillow lavas (Hayward & Moore this volume Fig.8) which are normal basalts, are overlain by acid tuffs and amygdaloidal basic lavas now represented by keratophyre and spilite.

It is now generally recognised that spilites are the product of low grade zeolite or greenschist facies metamorphism, either regional or hydrothermal (Cann 1969; Coombs 1974), in type, and Leitch (1978), has described hydrothermal metamorphism leading to spilitisation of the Whangakea Basalt which forms part of the mainland

nearest to the Three Kings Group. The mineralogy and texture of the basic lavas is similar except that the calcic plagioclase (An_{57}) of the basic pillow lava is replaced by albite in the overlying spilites, accompanied by a greater development of epidote chlorite and epidote — quartz veins. In some partly spilitised dike rocks (e.g. P44126) the feldspar has cores of labradorite diffusely zoned to oligoclase at margins of phenocrysts, and albite has replaced the groundmass feldspar. Sodium metasomatism has been followed or accompanied by potassium metasomatism resulting in the partial replacement of albite phenocrysts and groundmass in more amygdaloidal spilites and keratophyres, and crystalisation of K-feldspar round vesicles and veins in more massive rocks. The $K_2 0$ content of spilites and keratophyres from Three Kings Is is generally lower than in similar rocks from the mainland (Battey 1955, 1956).

Hydrothermal spilitisation of the Three Kings rocks appears to be fairly localised, as underlying sandstones and siltstones show little alteration apart from slight development of secondary quartz around detrital grains and in narrow veins with calcite. Zeolites are found only locally in some of the spilites and keratophyres (P44125, P44129); mainly thomsonite or, rarely, gmelinite (P44129). Prehnite is abundant in veins and lenses in basic tuffs, and calcite is present in veins, amygdales and groundmass of nearly all rocks.

The type of alteration, the minerals formed, and the relationship between porosity and permeability of the rocks and the localization and extent of alteration, can be compared to hydrothermal alteration in present day geothermal fields such as Wairakei (Steiner 1977) and Broadlands (Browne & Ellis 1970).

Nature of the volcanism

Pillow lavas in the sequence show that some of the volcanism must have been submarine, and the scarcity and small size of vesicles in the basal pillow lava on West I suggests that this unit was erupted at a depth of at least 200 m (Moore 1965). However, overlying the pillow lavas on West I are highly amygdaloidal spilites and keratophyre which is obviously an altered rhyolitic tuff of ash flow or air fall origin. The basaltic tuffs found on South West I and Rosemary Rock also point to shallow water, although material from ash flows and falls may be redeposited from higher levels on the flanks of island volcanoes and seamounts (Stanley & Taylor 1977).

It is probable that the Three Kings Is represent a group of Cretaceous volcanic islands or seamounts in which the initial volcanism was submarine, but continued activity rapidly built up the volcanic pile to near sea level. For short periods, activity may have been above sea level, allowing the eruption of rhyolitic ash flows. The scarcity of sediments between flows suggests that volcanism was either intense and short lived, or that later activity was partly sub-aerial.The co-existance of acid and basic volcanics is a worldwide phenomenon and has been well described from Iceland (Walker 1966) where rhyolitic flows and pyroclastic deposits make up about 10% of the Tertiary volcanic pile. In the Three Kings, keratophyre makes up far less than 10% of the sequence, but is significant on Great I and on West I. The volume involved here is not too great to preclude an origin by differentiation of a basalt magma, although a contribution from the quartzose and highly micaceous Tokerau Formation might be involved in the hydrothermal silicification and potassium enrichment of the rocks.

Correlation

The nearest volcanic rocks, the partially spilitised basalts of the Whangakea Volcanics in the Cape Reinga area, are petrologically extremely similar. Bartrum and Turner (1928) describe olivine bearing, basalt pillow lavas which are identical to those on West Island, and the spilites of the Whangakea Volcanics are also very similar. The submarine ridge between Cape Reinga and Three Kings is composed of basalt, including olivine basalt, and Summerhayes (1969) correlated these rocks with the Whangakeas. The presence of keratophyre on Three Kings, and its apparent absence in the Whangakea Volcanics, might favour a correlation with the Houhora Volcanics, which include keratophyres at Mt Camel and Doubtless Bay (Battey 1955). However, the Whangakea Volcanics include laccoliths or sills (F Brook pers. comm. 1985) of "granophyre" containing up to 40% modal quartz (Bennett 1976), and it is interesting to note that Bartrum (1929) described the Mt Camel keratophyres as "albitic granophyre". It may be that the Whangakea intrusions are feeding channels for acidic volcanism, not at present exposed in the North Cape area. The Houhora Volcanics do not contain olivine and the degree of alteration shown by the spilites of the Houhora Volcanics is greater; no unspilitised basalt has been reported, although alteration may depend on the distance from a heat source. The mafic-ultramafic pluton at North Cape is an obvious source, but further south, near Ngataki and Cape Karikari, there are significant positive Bouger anomalies indicating further centres of mafic intrusion. Mt Camel and Doubtless Bay would be very much nearer these centres than would Three Kings or Cape Reinga and it is significant that the basalts of the Cape Reinga volcanics are not spilitised whereas those further east are (Leitch 1978). More permeable rocks on the Three Kings are spilitised and K-metasomatised, but non-amygdaloidal rocks are unaltered, and it is probable that a centre closer than North Cape was the focus for the Three Kings volcanism.

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FISHES OBSERVED AT THE THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

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Abstract. Ninety-two species of fishes, representing 46 families, are recorded from the Three Kings Islands. An area influenced by both ocean surface water movements and cold water upwelling, the Three Kings region is characterised by a mixture of forms, with either warm or cold water affinities. Significant northward range extensions are noted for *Pseudolabrus cinctus* and *Pseudophycis barbatus.*

The majority of fish species listed here have been identified from visual and photographic records made during many summer SCUBA dives over the period 1982-86, as well as from specimens collected at poison stations, and by suction gun and handline, in late 1983 and early 1986. Some commercial species, taken in the immediate vicinity of the Three Kings Islands, are also included. It is clear that additions will be made to this list from time to time, as rarer species and/or occasional visitors to the Three Kings Islands are recorded. Nevertheless, it is hoped that the majority, if not all, of the fish species resident to depths of 46 m have now been noted. Any deeper resident fauna is largely unknown, although the bythitid, *Monothrix consobrinus*, was trawled from 173-178 m by R.V. *Tangaroa*, in 1981, and the creediid, *Limnichthys rendahli*, was reported from 117 m (as *L. fasciatus*), as early as 1926 (by Rendahl 1926).

A number of undescribed species, predominantly in the family Tripterygiidae, have been included in the list. Most of these species are well known by divers, and where appropriate, have been accorded the notation and common names given by Ayling (1982).

In the following list, an asterisk (*) or dagger (†) indicates that voucher specimens are held in the research collections of the National Museum of New Zealand, Wellington, (NMNZ) or the Auckland Institute and Museum, Auckland, respectively.

A total of 92 species, representing 46 families, are recorded.

Rec. Auckland Inst. Mus. 24: 243-250 18 December 1987

List Of Fishes At Three Kings Islands

Family Hexanchidae	
**Notorynchus cepedianus* (Peron, 1807)	Broad-snouted seven gill shark
Family Lamnidae	
Carcharodon carcharias (Linnaeus, 1758)	Great white shark
Family Triakidae	
Mustelus lenticulatus Phillipps, 1932	Spotted smooth hound (rig)
Family Carcharhinidae	
Galeorhinus galeus (Linnaeus, 1758)	School shark
Family Squalidae	
Squalus blainvillei (Risso, 1826)	Grey spiny dogfish (northern dogfish)
Family Dasyatidae	
Dasyatis brevicaudatus (Hutton, 1875)	Short-tailed stingray
Dasyatis thetidis Waite, 1899	Long-tailed stingray
Family Myliobatididae	
Myliobatis tenuicaudatus (Hector, 1877)	Eagle ray
Family Muraenidae	
**Gymnothorax nubilus* (Richardson, 1848)	Grey moray
Gymnothorax obesus (Whitley, 1932)	Speckled moray
Family Congridae	
Conger verreauxi Kaup, 1856	Common conger eel
**Conger wilsoni* (Bloch & Schneider, 1801)	Northern conger eel
Family Moridae	
†**Pseudophycis barbatus* Gunther, 1863	Southern bastard cod
†**Pseudophycis breviusculus* (Richardson, 1846)	Northern bastard cod
**Lotella rhacinus* (Bloch & Schneider, 1801)	Rock cod
Family Bythitidae	
**Brosmophyciops* sp.	Orange brotula
**Monothrix consobrinus* (Hutton, 1876)	Grey brotula
*?*Monothrix* sp.	
Family Gobiesocidae	
**Dellichthys morelandi* Briggs, 1955	Urchin clingfish
**Trachelochismus melobesia* Phillipps, 1927	Striped lumpfish
**Trachelochismus pinnulatus* (Bloch & Schneider, 1801)	Lumpfish
Family Trachipteridae	
**Trachipterus* sp.	Dealfish
A single planktonic juvenile collected	
Family Trachichthyidae	
**Optivus elongatus* (Gunther, 1859)	Slender roughy
**Paratrachichthys trailli* (Hutton, 1876)	Common roughy
Family Berycidae	
**Centroberyx affinis* (Gunther, 1859)	Golden snapper
Family Zeidae	
Zenopsis nebulosus (Temminck & Schlegel, 1845)	Mirror dory
Zeus faber Linnaeus, 1758	John dory
Family Syngnathidae	
**Hippocampus abdominalis* Lesson, 1827	Seahorse
**Lissocampus filum* (Gunther, 1870)	Short-snouted pipefish

Family Scorpaenidae	
Helicolenus sp.	Sea perch
†**Scorpaena papillosa* (Bloch & Schneider, 1801)	Red scorpion fish
Family Triglidae	
Chelidonichthys kumu (Lesson & Garnot, 1826)	Red gurnard
Family Callanthiidae	
Callanthias allporti (Gunther, 1876)	Splendid perch
Family Serranidae	
Caesioperca lepidoptera (Bloch & Schneider, 1801)	Butterfly perch
Caprodon longimanus (Gunther, 1859)	Pink maomao
**Ellerkeldia huntii* (Hector, 1875)	Red-banded perch
**Ellerkeldia* sp. (cf. *E. huntii*)	Half-banded perch
**Epinephelus daemelii* (Gunther, 1876)	Spotted black grouper
Family Percichthyidae	
Polyprion moeone Phillipps, 1927	Bass
†*Polyprion oxygeneios* (Bloch & Schneider, 1801)	Hapuku
Family Acanthoclinidae	
**Taumakoides littoreus* (Bloch & Schneider, 1801)	
**Taumakoides marilynae* Hardy, 1985	
Family Labracoglossidae	
†**Bathystethus cultratus* (Bloch & Schneider, 1801)	Grey knifefish
Family Carangidae	
Decapterus koheru (Hector, 1875)	Koheru
Pseudocaranx dentex (Bloch & Schneider, 1801)	Trevally
Seriola lalandi Cuvier & Valenciennes, 1833	Kingfish
Family Arripidae	
Arripis trutta (Bloch & Schneider, 1801)	Kahawai
Family Sparidae	
Chrysophrys auratus (Bloch & Schneider, 1801)	Snapper
Family Mullidae	
†**Upeneichthys lineatus* (Bloch & Schneider, 1801)	Goatfish, red mullet
Family Pempherididae	
**Pempheris adspersus* Griffin, 1927	Bigeye
Family Kyphosidae	
†**Atypichthys latus* McCulloch & Waite, 1916	Mado
**Kyphosus sydneyanus* (Gunther, 1886)	Silver drummer
**Scorpis lineolatus* Kner, 1865	Sweep
**Scorpis violaceus* (Hutton, 1873)	Blue maomao
Family Chaetodontidae	
Amphichaetodon howensis (Waite, 1903)	Lord Howe coralfish
Family Pentacerotidae	
Paristiopterus labiosus (Gunther, 1871)	Sowfish
Family Pomacentridae	
**Chromis dispilus* Griffin, 1923	Demoiselle
Chromis hypsilepis (Gunther, 1876)	One-spot puller
**Parma alboscapularis* Allen & Hoese, 1976	Black angelfish

Family Aplodactylidae	
**Aplodactylus arctidens* Richardson, 1839	Marblefish
**Aplodactylus etheridgi* (Ogilby, 1889)	Notch-headed marblefish
Family Cheilodactylidae	
Cheilodactylus ephippium McCulloch & Waite, 1916	Painted moki
**Cheilodactylus spectabilis* Hutton, 1872	Red moki
†*Nemadactylus douglasii* (Hector, 1875)	Porae
†**Nemadactylus macropterus* (Bloch & Schneider, 1801)	Tarakihi
Family Latrididae	
Latridopsis ciliaris (Bloch & Schneider, 1801)	Blue moki
Family Labridae	
**Coris sandageri* (Hector, 1884)	Sandager's wrasse
Pseudolabrus cinctus (Hutton, 1877)	Girdled wrasse
**Pseudolabrus fucicola* (Richardson, 1840)	Banded wrasse
†**Pseudolabrus miles* (Bloch & Schneider, 1801)	Scarlet wrasse
**Suezichthys aylingi* Russell, 1985	Crimson cleanerfish
Family Odacidae	
†**Odax cyanoallix* Ayling & Paxton, 1983	Bluefinned butterfish
Family Creediidae	
Limnichthys rendahli Parrott, 1958	Sand diver
Family Mugiloididae	
**Parapercis colias* (Bloch & Schneider, 1801)	Blue cod
Family Blenniidae	
Parablennius laticlavius (Griffin, 1926)	Crested blenny
Plagiotremus tapeinosoma (Bleeker, 1857)	Mimic blenny
Family Tripterygiidae	
**Forsterygion varium* (Bloch & Schneider, 1801)	Variable triplefin
**Gilloblennius tripennis* (Bloch & Schneider, 1801)	
Ruanoho decemdigitatus (Clarke, 1879)	Longfinned triplefin
Ruanoho whero Hardy, 1986	Spectacled triplefin
†**Karalepis stewarti* Hardy, 1984	Scaley-headed triplefin
**Notoclinus fenestratus* (Bloch & Schneider, 1801)	Topknot
**Notoclinops yaldwyni* Hardy, 1987	Yaldwyn's triplefin
Cryptichthys jojettae Hardy, 1987	Black-arched triplefin
Bellapiscis lesleyae Hardy, 1987	
*Gen. & sp. indet. (Ayling sp. 2.)	Mottled triplefin
*Gen. & sp. indet. (Ayling sp. 3.)	Yellow-black triplefin
*Gen. & sp. indet. (Ayling sp. 4.)	Oblique swimming triplefin
Family Clinidae	
†**Ericentrus rubrus* (Hutton, 1872)	Orange clinid
Family Gempylidae	
Thrysites atun (Euphrasen, 1791)	Barracouta
Family Balistidae	
**Parika scaber* (Bloch & Schneider, 1801)	Leather jacket
Family Diodontidae	
Allomycterus jaculiferus (Cuvier, 1836)	Porcupine fish

Discussion

The fish fauna of the Three Kings Is contains elements of both the northern offshore island fauna, and a more southern fauna. Overall, the region has somewhat lower fish species diversity than that seen in the warmer waters of the offshore island groups of the Hauraki Gulf and eastern Northland. Although ninety-two species are recorded, compared with only 76 from the Poor Knights Is (Russell 1971), (including several game fish species) the latter omitted a number of undescribed or unidentified taxa, as well as the more cryptic species.

A recent, unpublished report (Kelly unpubl.) listed 117 fish species from the more extensive Poor Knights Islands Marine Reserve (including game fish and other pelagic species). Although the species list contained in the latter report must still be considered incomplete, as evidenced by its inclusion of only six triplefin species, and a single clingfish, some interesting comparisons can be made. Thirty-five families are common to both the Three Kings Is and the Poor Knights Islands Marine Reserve. Within these families, 77 species are reported from the Three Kings Is compared with 91 from the Poor Knights Islands Marine Reserve. Only 56 species are known to be common to both regions. The most obvious disparity between the two areas is seen in the Labridae (five species from the Three Kings Is; 13 from the Poor Knights Islands Marine Reserve). Because the labrids are more readily observed and collected than some of the more secretive or cryptic families, such numbers probably reflect more realistically, the actual situation, rather than a bias or difficulty in recording species presence or absence.

The presence (or apparent absence) of certain fish species at the Three Kings suggest some interesting, if at times confusing patterns of distribution. Cold upwelling waters, responsible for low temperature and salinity anomalies in the Three Kings region (Stanton 1973), may provide a clue to the presence of the girdled wrasse (*Pseudolabrus cinctus*). However, the occurrence of Sandager's wrasse (*Coris sandageri*) and the crimson cleanerfish (*Suezichthys aylingi*), both northern species of sub-tropical affinities, appears to contradict the absence of other northern wrasses (e.g. *Pseudolabrus inscriptus*, *P. luculentus*) [see also Ward & Roberts 1986]. The absence of the spotty (*Pseudolabrus celidotus*), widespread and extremely common throughout New Zealand coastal waters, is perhaps compensated for by the larger densities of banded wrasse (*P. fucicola*) than are normally seen around the mainland coast. It would seem unlikely that temperature or salinity fluctuations are by themselves responsible for the absence of *P. celidotus*. Ward & Roberts (1986) noted that spotties were not commonly seen in waters of the east Northland offshore island groups.

Considerable northward range extensions are shown here for *Pseudolabrus cinctus* (not previously known north of the Wairarapa coast), and *Pseudophycis barbatus* (previous northern limit Bay of Plenty, Paulin 1983). A single, large bythitid, tentatively identified here as ? *Monothrix* sp., is the second example of this undetermined species recorded in New Zealand, a smaller specimen having been trawled in 107 m off Cape Runaway by R.V. *Tangaroa* in 1979 (NMNZ P. 7830).

A number of workers have noted the cold water affinities of aspects of the fauna and flora of the Three Kings marine environment. Disregarding those species endemic to the region, marine algae are characterised by both temperate and cold water species, resulting from major ocean surface water movements, and cold water upwelling. Especially significant are records of cold water species and some genera (e.g. *Desmarestia*), otherwise not known north of Cook Strait (N.M. Adams, pers. comm.) — a pattern reminiscent of *Pseudolabrus cinctus*. Hurley (1953) regarded the amphipod fauna of the Three Kings as atypical of the surrounding northern waters, having cold water affinities, and similar observations have been made (G.R.F. Hicks, pers. comm.) for harpacticoid copepods.

Although high numbers of individuals were not obvious, the Tripterygiidae (triplefins) is the most widely represented family in terms of species. Each of the 11 species recorded is known also from southern New Zealand, with 7 of them having been collected during a recent survey of the Snares Islands. Clearly, notions of a restricted "northern" tripterygiid fauna in New Zealand (Ayling 1982), are no longer tenable, and the Three Kings' tripterygiid fauna can be considered to comprise species well represented around much of New Zealand. If anything, the triplefin fauna of the Three Kings comprises fewer species than might have been expected, as recent surveys (by G.S.H.) of Fiordland and the Sugarloaf Islands, off Taranaki, have resulted in the collection of 18 triplefin species from each region. In view of its widespread occurrence around New Zealand, having been recorded from the Marlborough Sounds, Kaikoura, and Fiordland, as well as from the Northland east coast and offlying islands, the undescribed "blue dot" triplefin has, surprisingly, yet to be seen at the Three Kings. Other common species around the North and South Is, *Forsterygion capito, Notoclinus compressus, Bellapiscis medius*, and *Notoclinops segmentatus*, are also unrecorded from the Three Kings. Common wherever they occur, these species may be restricted by nuances of habitat, not yet understood. Other, seemingly ubiquitous species, such as *Gobiopsis atrata, Taumakoides rua* and *Odax pullus* are also unrecorded from the Three Kings region, although suitable habitat seems to be present. Indeed, *O. pullus* is replaced at the Three Kings by *O. cyanoallix*, a species known elsewhere only from one specimen photographed at the Poor Knights (Ayling & Paxton 1983) and several seen at Cape Reinga in early 1986 (M.P.F. pers. obs).

Of the serranids observed at the Three Kings, the ubiquitous cold water species, *Ellerkeldia huntii*, is perhaps less commonly observed than an undescribed congener, a reverse of the mainland situation in which *E. huntii* is the more common. Of the other serranids observed at the Three Kings, *Caesioperca lepidoptera* is an ubiquitous species, often locally very abundant at least as far south as the Snares Is, and *Epinephelus daemelii* is now known to extend down the west coast of New Zealand, at least to Westport. The southern splendid perch, *Callanthias* sp. (placed in Callanthiidae following Johnson 1984), known from Fiordland and the Snares Is, is believed to represent a species distinct from the northern *C. allporti*, reported from the Three Kings.

Other species, common throughout north eastern New Zealand waters, but apparently absent from the Three Kings Is, include *Gymnothorax prasinus, Chironemus marmoratus, Girella tricuspidata,* and *Bodianus vulpinus.* In addition, the subtropical serranids, *Acanthistius cinctus* and *Trachypoma macracanthus*, occasionally seen at the islands off eastern Northland, are also unrecorded.

NOTE ADDED IN PRESS

Roberts (1987) recently recorded for the first time several demersal fish species, including *Pseudophycis barbata* (*sic*), from the North Cape-Three Kings region.

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RECORDS AND BULLETIN OF THE AUCKLAND INSTITUTE AND MUSEUM

Instructions for Authors

The *Records* and *Bulletins* contain the results of original research dealing with material in the collections of the Museum, and research carried out by members of the Museum staff in their particular subjects. The fields covered are usually anthropology (archaeology and ethnology), botany, geology and zoology, although any aspect of the Museum's work and collections may be included.

Before completion of a manuscript, authors should refer to papers on a similar subject in the most recently published volume for detail of format required. Any doubts should be referred to the Editor. Standard rules for scientific papers and taxonomy apply; an acceptable guide for style is the New Zealand Government Printing Office Style Book (1981 edition).

Manuscripts should be typed, double-spaced on one side of white International A4 or foolscap sheets, with a 2.5 cm (or 1 inch) margin on *both* sides of page. Two copies of text are required, second copies of figures are preferred but not demanded. Manuscripts should not be in booklet form, but supplied with figures, figure captions, tables with captions above, all separate, with only an indication of position required in the text.

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Figures (particularly groups of figures) and tables should be composed to page proportions, with due regard to saving space, and must be supplied ready for reduction (where necessary) to the printed page size or less (allowing for captions — above tables, below figures), preferably upright on page but sideways on page accepted (where necessary). Figures for fold-outs will only be allowed in special circumstances. Individual figures (whether grouped or not) should be numbered consecutively in arabic numerals (*not* 1a, b, c, etc) regardless of whether they are photographs or line drawings. Figures and tables *must* be referred to in the text and should be numbered in order of reference where possible.

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